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THE
MICROBIOLOGY AND MICROANALYSIS
OF
FOODS

BY

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WITH 131 ILLUSTRATIONS

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PREFACE

This volume is intended as a guide to the study of the microbiological decomposition changes in foods. It also presents a practical working basis for ascertaining the decomposition limits of foods suitable for human consumption, by means of the direct methods of microanalysis. The microanalytical examination of milk, of water and of other beverages is included.

While the text is addressed to army dietitians and food examiners, it will be found equally suited to the needs of the dietitians, medical officers and food examiners, in the navy, and by analysts in food laboratories of all kinds (federal, state, municipal and private). It will serve as a text and laboratory guide for students in universities and colleges where courses in dietetics, in home economics, in food testing, in food decomposition, in food analysis, etc. are given. Many of the colleges of pharmacy, and also other colleges and technical schools, give special courses intended to qualify students as analysts in food and drug laboratories. The present volume will be found a useful guide for such students. The microanalytical methods outlined are those in use at the present time. The proposed food ratings are based upon many years of practical experience in the examination of all kinds of food products and are believed to be fair to both consumer and manufacturer.

Grateful acknowledgments are made to Major Samuel C. Prescott, office of the Surgeon General, War Department, Washington, D. C., at whose suggestion the book was prepared and who gave the manuscript a critical reading.

A. S.

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April, 1920.

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INTRODUCTION

The importance of good food, and plenty of it, cannot be overestimated. Clayton (Food Microscopy, 1908) makes the following significant statement: "A recruiting return (British) supplied early in the present year (1908), in reply to a question in the House of Commons, showed that one half of the young men offering themselves were unfit for military service. In view of the disgraceful facts which of late years have come to light, concerning the nature, origin and preparation of the foods, mostly, but by no means exclusively, consumed by the working classes, the inference is irresistible that bad food, much of it doubtless derived from diseased animals, was at least in part responsible for so grave a state of affairs." In this percentage of rejects, those who were so evidently unfit as to preclude them from the medical examination, were not included. Our own recent (1917) recruiting experiences in certain parts of the United States were almost equally startling. It may be that Dr. Clayton overestimates the part played by bad and insufficient food. The physical inferiority of our youth is a matter of generations of poor physical inheritance, of inadequate physical training, of vicious habits, and of perverted nutrition due to improper feeding, rather than insufficient food.

Pryor (Naval Hygiene, 1918, p. 128) makes the following statement.—"Perhaps no essential to the efficiency of a fighting force has received so little attention in detail as its food. Want of proper food broke the power of Napoleon's army in Poland in 1806. It led to his retreat from Moscow in 1812. It caused disaster to the British in Crimea and hastened the fall of Port Arthur. Eight thousand Russians were in hospitals alone in Port Arthur when the fortress fell. Most of them were sick of scurvy, a preventable disease, due to improper feeding. Had they been well fed and equipped these 8,000 men could have delayed for a long time the surrender of the fortress."

The physical degeneration and general bodily demoralization of those who do not receive proper and sufficient food, for even short periods of time, has time and again been made glaringly apparent in prisoners of war, and even in the men at the battle fronts of the World War. There have been extensive outbreaks of food poisoning in some of the home encampments due to bad food (mostly meats and canned foods). The symptoms were those of acute enteritis with great prostration. Features pale and drawn for two or three days, with great muscular weakness. No fatalities were reported. Major Samuel C. Prescott reports that there was little or no trouble due to bad food in most of the larger encampments where the food purchases were properly supervised and where certain food inspections were made. However, the inadequacy of the army food inspections has been brought out in civil court proceedings under the state (California) pure food act. On several occasions, canners fought condemnation procedures based upon laboratory findings, because according to testimony, the Army Quartermaster division had pronounced the food article in question, satisfactory.

During our participation in the World War and since the declaration of the armistice and the demobilization subsequent thereto, numerous reports of extensive outbreaks of severe enteritis in army encampments, in barracks and on transports have been made by privates, mess sergeants, camp cooks and by officers. All of the reports were quite uniform as to the symptoms of the food intoxications. Generally a severe enteritis with great prostration, lasting from three to five days. In one aviation barrack, housing about 5,000 men, fifty per cent. were thus stricken after an evening meal. No thorough investigation was made. The mess sergeant laid the trouble to bad meat. In one large training camp severe and extensive outbreaks of enteritis developed with some regularity, usually at the close of the week, suggesting to the men that they were given a periodic purgative with the food. A committee of privates called on the commanding officer and asked if this were so, and if so, urged that the dose be much reduced as the effects were too severe. The officer declared that there was nothing to the surmise of the men. No special investigation was made and the conclusion reached was that the attacks were caused by bad food, coupled with the increase in unsanitary conditions of the mess toward the close of the week. Several extensive outbreaks of enteritis appeared in the S. A. T. C. barracks of one of our large universities. No thorough investigation was made. Reports of the kind cited could be multiplied many times. They serve to emphasize the importance of army sanitation as well as the importance of properly inspecting and testing the food supplies intended for the men.

A most serious drawback to the cause of purer and better foods is the inability on the part of many, if not most, food bacteriologists to get away from the plate culture method for determining food decomposition, and also because many, if not most, laboratory analysts have had such limited practical experience in food inspection, food production and preparation, etc., as to make it impossible for them to make proper use of the organoleptic tests. There are many technically experienced food analysts who assert that a direct bacterial count is of little value as an indicator of the quality of the food article, whereas in fact it is the most valuable analytical factor now in use. Particularly is this the case in the examination of all foods which are much handled or which are long stored. The direct microcopical examination is the only means we have for determining the pre-processing condition of canned foods, of dried foods and of frozen foods. Food materials in cans may be entirely decomposed and yet the plating results may be wholly negative. In these cases the direct microscopical examination will reveal billions of dead bacteria per cc. or per gram. The direct bacterial count is the simplest and the most practical means for determining the quality of sausages of all kinds, of pastes, of minced meats, of potted fish and other meats, of gelatine, of dried, smoked, kippered and otherwise preserved meats and of frozen and cold storage meats, of dried milk, dried eggs, dried egg albumen, etc. In every case the organoleptic tests must be very carefully made and intelligently interpreted. The relationship of the direct count and the plating methods, as far as field work is concerned, may be summarized as follows. The direct count is all important and the plating methods (and other special cultural methods, including special staining methods) are quite secondary in significance; and the direct count must be supplemented by the organoleptic tests. The commercial grading of food products of all kinds depends upon a good general knowledge of the growing of food plants, the rearing of live stock, the dairying industry, etc., and the handling of food products, and a reasonable and rational interpretation of the findings based upon the organoleptic tests. While the army food analyst should be able to grade food products as to quality, size, variations in color, form, etc., he will have little time or opportunity to make practical application of minor nonessential grade differences and characteristics, because the all important thing to be determined in the field is whether or not the food product is wholesome, giving but little heed to those purely esthetic features which may please the sense of sight merely. For example, eggs for the army should be fresh and wholesome, it being quite immaterial whether or not they are of large or small size, or quite irregular as to size. Grade "A" and "B" milks are of equal value to the army. Many of the dried food substances especially intended for army use, are anything but pleasing to the sense of sight and taste, yet they are highly nutritious, etc.

The food microanalyst should also, as time and opportunity will permit, assist the work of the sanitarians, for next to the supplying of sufficient wholesome food, the sanitation of the men must be looked after. The men should have specific instructions regarding the infections peculiar to army life in times of peace as well as in times of war. In times of active warfare the filth infections are of the utmost importance. During the World War, the body louse and typhus were factors which were directly responsible for the failure of more than one carefully planned campaign.

There are many very useful works on army and navy hygiene and sanitation which must be consulted, however not to the neglect of the classic works on general sanitation, such as those by Rosenau and Sedgwick. It is to be assumed, however, that the qualified microanalyst is thoroughly familiar with the general principles of sanitation and preventive medicine and that he can make sanitary observations and analyses without specific and detailed instructions on the part of the sanitary officer, more especially those observations and analyses which may serve as a safeguard against the transmission of infections.

In many instances, protection against one infection also protects against other infections. About 1893, two health officers (H. F. Mills of the Massachusetts state board of health and Dr. J. J. Reincke of the Hamburg city board of health) noted that a reduction in deaths from typhoid fever, due to improved water sanitation, coincided with a reduction in mortality from causes other than typhoid. This is known as the Mills-Reincke phenomenon and has received much attention on the part of health officers everywhere. This observation is however not so recent as is indicated by the date given. For many years, it has been general knowledge among observing health officers and practicing physicians, that an improvement of those conditions which reduced the mortality rate due to any one of the more or less serious intestinal infections, reduced the general mortality rate likewise, and it has been surmised for many years that some kind of cooperative or symbiotic relationship existed between all filth borne pathogens and toxigens. It makes little difference against which one of the many kinds of filth germs the sanitary activities of a city or community are primarily directed, the end result will be a reduction in all of the filth borne diseases. A thorough and complete sanitary cleanup of a city means a reduction in the following diseases, naming them in the order of their more usual pathogenetic relationship. The entire series of intestinal infections, as the diarrheas, dysenteries, enteritis, colitis, cholera infantum, cholera morbus, etc., and typhoid fever, tuberculosis (including both the bovine and human types), diphtheria, and incidentally also syphilis and gonorrhea. The coincident reduction in the so-called social diseases is no doubt due to the fact that a purely physical cleaning up, encourages or stimulates moral cleanliness. To the list of essentially filth borne diseases must be added Asiatic cholera, amebic dysentery, bubonic plague, and other diseases, endemic and epidemic in certain countries. The exact causality of some of the supposedly water borne diseases, such as goiter, has as yet not been fully worked out.

As early as 1886–1887, the writer was strongly impressed by the high rate of intestinal diseases in the city of Chicago and surmised some causal relationship between the dysenteries and typhoid. Since the completion of the Chicago canal, the general health of that city has improved wonderfully. Up to that time, the sewage of the city was dumped into lake Michigan (*via* the Chicago river) and again pumped into the city and the inhabitants were obliged to swallow the mixed human and animal excreta. The accumulation of the sewage in the sluggish stream gave rise to an indescribable stench, still fresh in the memories of the older members of the present generation. The digging of the sanitary canal and the proper diverting of the city sewage, is the grandest and best thing ever done by the city of Chicago.

Phenomena akin to the socalled Mills-Reincke phenomenon have been observed in many other lines of sanitation and preventive medicine. Thus the Hookworm Commission of the Rockefeller Foundation in its report for 1917 makes the following statements. "Moreover, persons harboring the infection (hookworm) seem to be more susceptible to diseases such as malaria, typhoid fever, pneumonia and tuberculosis. Measles occurred more frequently (ratio two and one-half to one) in men who had hookworm disease. Figures showing a remarkable reduction in sickness calls, for all diseases, following treatment of estate laborers for hookworm disease, are furnished by the superintendent of seven estates in Ceylon. This would seem to indicate that the improvement in health effected by the treatment for hookworm disease resulted in the patients being more readily cured of other diseases. There was a marked decrease in bowel complaints and in malarial fevers."

In brief, the far-reaching beneficial effects of sanitary measures cannot always be foretold or foreseen. We need, in fact, some systematic form of instructing the public regarding sanitation and disease prevention. Army and Navy sanitary officers should be more fully informed in such matters in order that they may more convincingly impress the principles of sanitation upon the men.

The following suggestions are to serve as a guide for the dietitians and the food microanalyst, in the inspection and examination of food materials in times of war as well as in times of peace. As above indicated, it should also be the duty of the field microanalyst to cooperate with the sanitary officers in maintaining the efficiency of the men. His special skill and training will also be of great value to the officers in charge of sanitary work, and to the army surgeon, and in certain phases of the secret service.

It is perhaps obvious that the methods which are practical in the field service, are in many ways essentially different from those employed by analysts in civilian food and technical laboratories. The everchanging conditions and situations which prevail during times of war, make it practically impossible to formulate detailed field methods; furthermore, the analysts assigned to duty in the field and in the camp, must be sufficiently experienced to enable them to develop and to adapt the suggestions herein given to the arising exigencies. The field equipment must be extremely simple and compact, always ready for immediate use, anywhere and at all times.

The advice and the recommendations of the food microanalyst will be of no avail unless the commanding officer acts upon them. The analyst must at all times have free access to all food supplies intended for the army and he should at all times have the heartiest assistance and cooperation of all mess officers, and of the unit or detachment commander. No foods should be purchased by the Supply Department unless first examined and passed upon by the micro-analyst.

It is the duty of the microanalyst to make accurate reports of his findings, including correct interpretations of such findings, with a carefully weighed and considered recommendation as to the disposal of the food substance under consideration.

I. DECOMPOSITION CHANGES IN FOODS

Decomposition changes are always destructive or catabolic and are to be contrasted with composition changes or metabolic changes. Metabolic changes proper take place in living and growing plants and animals. From the very nature of things, the only changes which can take place in food substances are destructive or catabolic or enzymatic in character. The object to be attained in food preservation is to retard or check these decomposition changes as much as possible. There is, however, no process known to science which will completely inhibit food decompositions.

Some food decompositions are considered to be harmless or even desirable (cheese, sour milk, Sauerkraut, etc.), while others are decidedly injurious. It is the work of the microanalyst to ascertain those decomposition changes which are undesirable, or injurious to health.

Food deficiency may bring on disease. Lack of vitamines is said to be responsible for scurvy, beriberi and perhaps pellagra. It has even been suggested that cancer may be the result of a prolonged diet of foods lacking in vitamines. No less disturbing are food excesses, which may give rise to auto-intoxications, rheumatic affections, gout and certain forms of mental lethargy.

More or less severe and more or less atypical cases of food poisoning are very common and there is a most unfortunate tendency to ignore or quite overlook many of these cases. The efficiency of an entire company may be paralyzed, temporarily at least, through the eating of a single meal of unwholesome food. In some of these cases it is not easy to determine whether the trouble was primarily due to indigestible or improperly prepared food, or to decomposition changes, or to toxin formation in the intestinal tract, or perhaps to food anaphylaxis.

The men should be warned against sampling or eating wild growing berries, roots and vegetables, found along the lines of march or near encampments, as they may prove poisonous or may set up serious intestinal disturbances. Especially should they be warned against green fruit, green vegetables and toadstools. No food should be eaten which has not been passed upon and recommended by the nutrition expert.

1. Food Spoilage due to Decomposition and Infection.

(*a*) **Bacterial Decompositions.**—All classes of foods may become decomposed by bacteria of decay, and all foods so decomposed or undergoing such decomposition, are unsuitable for human consumption. Bacterially decomposed foods show more or less pronounced changes in color, in consistency, and in odor. However, bad odor, softness of tissues, and changed color, are not the only criteria upon which the quality of the food shall be based. The danger point is generally reached before the decomposition changes are sufficiently marked to obtrude themselves upon the unaided sense organs. Numerous cases of food poisoning occur each year from eating food which is considered good, judged by the color, odor, taste and consistency (organoleptic tests). Other foods may be considered "slightly off" as to odor and consistency, but are nevertheless eaten, often with disastrous results. Each year there are thousands of cases of more or less mild to more or less severe intoxications due to eating partially decomposed food, served in restaurants, in buffet cars, in camps and even in private homes. A considerable number of these cases of intoxications are traceable to canned foods.

At what stage in the development of bacterial food decomposition shall the food be rejected as unsuitable for human consumption? It is evident that since the bacteria of decay are practically omnipresent, all foods contain some of the organisms, either living or dead, or both kinds. To reject all foods which contain appreciable or measureable quantities of rotting bacteria, would, therefore, practically mean the rejection of all foods. On the other hand, if we reject only those foods which show signs of decay that are unmistakably evident to the unaided sense organs, we would fail utterly in the proper safeguarding of the health of the consumer. We may offer the incontrovertible statement that all sound wholesome properly prepared and properly preserved foods, contain rotting bacteria in negligible quantities only. With the exception of the well-known and more or less carefully regulated enzymatic food decompositions (souring of milk, ripening of cream and cheese, Sauerkraut, soja sauce, and other fermented foods, inclusive of fermented drinks), we may set a reasonable and practical limit to the permissible number of rotting bacteria in foods of all kinds. It would be wholly impracticable, if not impossible, to determine the toxicity (due to ptomaines, toxins, toxalbumins) of the various bacteria which may appear in foods. All bacterial food decompositions which are not regulated and controlled and proven comparatively harmless, are to be considered injurious, when the decomposition has reached the limits elsewhere suggested. Furthermore, it makes no difference whether the organisms present in unfermented foods are dead or alive, or whether they are proven harmless or harmful, nor is it even necessary to prove them to be of the rotting variety. When bacteria, of any kind whatsoever, are present to the numerical limits proposed under microanalytical rating of foods, it is to be taken as presumptive evidence that they are rotting bacteria, or otherwise objectionable bacteria, and hence injurious to health, and foods containing more bacteria than are indicated by these limits, are to be rejected as unsuitable for human consumption.

There are foods that contain the toxic products of bacteria but which do not show bacteria or other microorganisms, having acquired such toxic substances by absorption (osmotic interchange) through contact with, or osmotic proximity to, bacterially decomposed foods. Such spoilt foods are, however, comparatively rare and they are, as a rule, readily detected because of their usually close proximity to the foods which actually harbor the microorganisms which gave rise to the formation of the toxic agents. Generally, the marked decomposition of a portion of a food mass necessitates the rejection of the entire mass. A jar of caviar with putrid decomposition of the upper layer should be rejected. A ham which is partially decomposed should be rejected *in toto.* A mass of sausage meat showing superficial decomposition should be rejected. it is not practicable to cull out the spoilt pieces of meat from a mass in a vat, cask or barrel. The entire lot must be rejected.

The chief products of animal putrefaction are sepsin, cadaverin and putrescin, three chemically highly complex organic compounds which appear to be genetically related and which are highly toxic to higher animals. Cholin may develop in decomposing fats, in bile, in seeds, in brain substance and in the yolk of eggs. Acetyl-cholin is highly toxic. Moldy corn, badly ripened cheese, decaying fish, rotten meats and spoilt foods generally, contain toxic substances, as demonstrated by Panum, Selmi, Bergmann, Brieger, Lombroso, Ostertag, and many other investigators. Vaughan has done an enormous amount of work on the chemistry and relationship of the animal ptomaines, some of which are pronounced harmless or nearly so, while others are highly toxic. It is now generally admitted that the putrefactive changes in animal substances (also in vegetable substances) are graded and very complex, and that as a rule, a number of different species of microorganisms are concerned, which organisms appear to bear some symbiotic relationship to each other.

The degree of putrefaction is not necessarily parallel to the degree of the toxicity produced. In a general way, a maximum toxicity is soon reached, after which the further rapid decomposition changes result in an actual reduction in the toxicity. Highly decomposed products may be, and generally are, most offensive to the sense of smell, and yet may be non-toxic. Meats reach their highest toxicity from the third to the fourteenth day of putrefaction. The highly offensive cheeses (Limburger, Bré, Roquefort) are generally quite non-toxic, whereas the milder though perhaps badly ripened cheeses may be quite objectionable from a sanitary point. The terrific stenches arising from openly exposed putrefying animals, serve as a sign to the scavenger animals, as the buzzards, that the danger period of toxicity has passed, and that it may be eaten with impunity. It is to be remembered, however, that toxic reactions are comparative and racial. From the standpoint of human sanitation, all putrefying food substances are unfit for consumption, whether toxic or not.

(*b*)·**Dangerous or Harmful Bacterial Contamination.**—Certain pathogenic and saprogenic bacteria may occur in and upon food substances and when such foods are eaten, may give rise to various disorders and diseases, such as simple diarrhea, bacillary dysentery, epidemic sore throat, typhoid fever, paratyphoid fever, and Asiatic cholera. Of the bacterial infections of foods, those responsible for the greatest amount of disturbance to the army, are the group of dysentery bacteria. These organisms are very widely distributed. They occur upon a great variety of food materials and are derived from sewage, from contaminated water supplies, from sewage an filth contaminated vegetables and from the hands, fingers and finger nail deposits of human carriers. Flies are among the most active distributors of the dysentery bacilli. The dysentery bacteria cause more deaths than the typhoid and cholera groups put together. The records show that in the wars of the past, the deaths from diarrhea and dysentery far exceeded those due to typhoid, and the fatalities increased as the war progressed. According to Ford, dysentery was responsible for 57,265 deaths in the Federal armies during the Civil War, corresponding to a yearly mortality of 17 per 1000, or one death out of every 3.5 deaths from all sickness. Were it possible to furnish soldiers with pure drinking water and clean ripe vegetables and could flies be kept away from the mess and men, and could the men be induced to keep hands, face and body clean, then dysentery would vanish from the army camp.

Green fruit, improperly cooked foods, and other indigestible foods, and food intoxications, are frequent secondary causes of dysentery. Other secondary causes of army dysentery are exposure to inclement weather, bad air, damp soil, excess of salts in drinking water and sudden changes in food and drink. Perhaps the most frequent inciters of epidemic dysentery are the more or less pronounced decompositions in foods, as already mentioned. There is yet another condition giving rise to dysentery and other diseases, which has not received the attention which it merits. Some species and varieties of bacteria, as for example certain strains of the human *Bacillus coli*, may under certain conditions, and without change of host, develop pathogenic qualities. Again, certain bacteria, which are ordinarily harmless or even beneficient to a given host, may, upon passing through a second host, become pathogenic to the original host. There is also some evidence that a harmless or indifferent bacillus, as the *Bacillus coli*, and other intestinal bacteria, may become pathogenic when transferred to another host of the same kind. It may be that this pathogenicity is developed during the time that the bacillus exists outside of the host as in water, upon the exterior of the body, in sewage, upon vegetables, in soil, in and upon insects as flies, etc.

The dissemination of such diseases as typhoid fever, Asiatic cholera, infectious sore throat, influenza, bacillary dysentery, diphtheria, pneumonia, tonsilitis and other essentially pathogenic bacterial infections, by means of foods, water supplies, milk, filth and carriers of many kinds, is well known to science and need not be discussed at this time.

(*c*) **Mold Decomposition.**—Mold in foods is quite generally recognized as objectionable; one of the exceptions being mold ripened cheese. The question of prime importance is to acertain the permissible limits of moldiness in foods. Most molds generate a peculiar odor, designated as musty or moldy, and all unfermented and unripened foods giving off such odor should be pronounced bad without hesitation. Under certain conditions the contaminated foods may not give off any appreciable mold odor and yet they may contain an excess of the mold. As is known, some cheeses are mold ripened, but these are to be eaten in limited amounts only, nor is it conclusively proven that they are wholly harmless.

Mold decomposition differs from bacterial decomposition in that it is usually much more clearly delimited in area and that, as a rule, no soluble toxins or toxalbumins or ptomaines are formed which might osmose into the adjacent uninvaded area of the food. For example, if the mold rot is cut out of an apple, the remainder may be eaten with impunity. Mold (*Penicillium glaucum*) can be removed from the top of a jar of jam and the remainder may be found wholesome. All apple eaters will, however, clearly recall how essential it is that every bit of the mold rot be removed as the least trace conveys a most pronounced disagreeable taste and flavor. The limit of wholesomeness of foods is soon reached if the mold is incorporated in it, as in tomato products, in jams and jellies, in pastes, and in certain drinks. Mold may occur excessively in nuts, cereals, beans, peas and in fruits of all kinds. In fact, mold is the chief cause of rotting of fruits. Mold is likely to occur upon the exterior of dried meats and smoked meats, and occasionally in the connective tissues and muscle tissue of fish and other animals, sick or dead of parasitic mold diseases.

Foods which are fresh and wholesome, contain mold in negligible quantities only. This statement does not even exclude the mold fermented cheeses (Bré, Roquefort), as it is the mold which they contain which precludes them from the list of the regular articles of diet and places them in the category of the occasional table relishes, for those who have a taste for them.

(*d*) **Yeast Decomposition.**—Yeasts require abundant moisture, air (available free oxygen), and sugar, as life essentials. They may, therefore, be looked for in fruit juices, in juicy fruits and in sugar solutions and in all of high the water content foods containing some sugar. They cause gas formation in the substances which they invade and frothing, foaming and bubble formation and a characteristic vinous or alcoholic odor are noticeable when yeast fermentation is active. They attack a great variety of food substances catabolizing the essential food ingredients, not only reducing the food value but also giving rise to more or less disagreeable aromas and flavors. Wild yeasts cause much trouble in wineries, breweries and in canneries. While there are only a comparatively few yeasts pathogenic to man, yet all are objectionable in foods for the reasons above indicated. All yeast fermentations are destroyers of foods (starch and sugar). The breweries each year use up vast stores of grains, preparing these as food for the yeasts, by first converting the starch into sugar, whereupon the yeasts split up the sugar into alcohol and carbonic acid gas. This gigantic food waste should be prohibited or reduced to a minimum. This also applies to wine making, saké making, etc. Not only is the food decomposed chemically but we convert it into a poison (alcohol) which destroys many lives each year; a poison which once paraded under the name of a useful medicine and stimulant but which has recently been unhesitatingly repudiated by the American Medical Association.

While most of the yeasts are non-pathogenic and non-toxigenic, there are some notable exceptions. The pathogenicity of some species is as yet not fully worked out. Yeasts are associated (secondarily) with certain pathologic states. Klebs at one time believed a yeast like organism to be the cause of cancer. It would appear that certain yeasts, which are ordinarily harmless to man and lower animals, may under certain conditions, become highly toxic. A considerable number of yeasts are parasitic upon higher plants and upon animals. The yeasts are also frequent symbionts with anaerobic bacteria, being more or less essential to the existence of the latter. Thus they may be the associates of such anaerobes as the *Bacillus botulinus* and *B. tetani.* Yeasts should be only sparingly present in unfermented food substances. If unusual forms should appear in considerable numbers in any food substance, such food substance should be rejected.

Some of the yeasts are highly polymorphic, the vegetative cells undergoing great changes in size and in form. This applies especially to the parasitic and toxigenic species. The greatly elongated cells may be mistaken for hyphæ of higher fungi (molds). In addition to the vegetative cells which increase in number by a process known as budding, there are spores formed in specialized cells. Spores may arise from gametically fused vegetative cells and again they may result from septations taking place in certain vegetative cells. The yeast spores often present extreme modifications in size as well as in form. They may be spherical, bacteroid in size and form, and long spindling. It may be that many of the bacteria-like cells found in and upon vegetables, vegetable extracts and in infusions, are yeast spores.

A large yeast obligatively parasitic in the stomach of sheep, rabbits and guinea pigs, causing the death of many animals, formed abundant spores measuring from 3 to 5 microns in length and 1.5 microns in diameter. These spores are formed in the large intestine of the infected animals, pass out with the excreta and are subsequently scattered by air currents. Is it likely that some of the cases of autointoxications in humans are due to parasitic yeasts. It must be born in mind that the vegetative cells of some of these parasitic yeasts endure in the stomach of the animal during the period of stomach digestion only, and in the presence of one or two kinds of food substances. Such parasitic yeasts appear to be quite common in the herbivora.

(*e*) **Amebic Contamination.**—Amebæ are essentially aquatic in habit and many of them feed upon rotting bacteria, yeasts and other micro-organisms associated with decay. They live in decaying vegetable matter immersed in water. They are the associates and symbionts of rotting bacteria, of diatoms, desmids, nostoc and other fresh water algæ. As factors in food decomposition, amebæ are wholly negligible. Although they occur as the associates of rotting bacteria, they do not in themselves cause any marked food decomposition.

A few species of pathogenic amebæ occur upon (in the resting stage) fruits and other vegetables in tropical countries. Of special importance are those species which cause dysentery. The ripe banana has been suspected of being the carrier of amebic dysentery. Recent observations would indicate that salads, sliced cold meats (ham, bacon, tongue, sausages) in sandwiches, and foods kept in the refrigerator or on ice over long (in tropical countries), may contain the amebæ of dysentery. Under no circumstances should water cress be used for making salads. It is likely to be contaminated by various objectionable micro-organisms (*B. coli*, streptococci, *B. typhosus*, pus organisms, etc.). Fruits having a high water content, as the tomato and even the grape, have been suspected as carriers of pathogenic amebæ (dysentery, pyorrhea).

It is believed that certain amebæ are normally present in the mouth and in the intestinal tract (*Endameba buccalis*, *E. coli*) and it may be that these do no particular harm, neither is there any evidence that they are beneficial. The pathogenic Endamebas, although actively feeding upon the abundant bacterial flora found in the areas which they invade, form an antagonistic relationship with man, which may be called *paracytosis*.

(*f*) **Cellular Disintegration.**—*Cytolyses. Patrocytosis. Sphærocytosis.*—It has been known for a long time that plant and animal cells and tissues gradually undergo disintegrative changes, no doubt due to the presence of enzymes. Cellulase gradually destroys the cell-walls of plant cells. Amylases are quite active in decomposing the starch within the cells, and the various proteins are gradually broken up by the proteases. In the absence of all decay producing organisms and in the absence of moisture and warmth, these lytic processes proceed very slowly, requiring years of time in which to produce marked changes.

As fruits and vegetables become mature, substances are formed within the cells which tend to retard the lytic changes just referred to, and which also ward off the invasion by rotting organisms (bacteria, yeasts, molds). The indications are, that some of these anti-bodies are formed in and exist in the sphærocytes (cell-like units found within the cell and derived from the cell-plasm) which are especially abundant in fleshy fruits. These special cell-like units, though derived from the cell-plasm, are nevertheless independent biologically, being able to continue their existence outside of the cell, even developing into mature cells and forming new tissues (neoplasms). They form a marked mutualistic symbiosis with the tissue cells from which they are derived. This form of symbiosis may be designated *patrocytosis.* The formation of sphaerocytes from the cell plasm of the mother cells and their extrusion into the cell lume and into intercellular spaces, may be designated *sphaerocytosis.* Sphærocytes are especially abundant in fully ripened tomatoes. They are also abundant in ripe grapes and have been noted in other fruits. There can be little doubt that the sphærocytes have to do with the keeping qualities of fruit and of other vegetable substances. Whether the plant sphærocytes serve any useful or beneficial purpose when ingested, has not yet been ascertained. No harmful properties have as yet been ascribed to them.

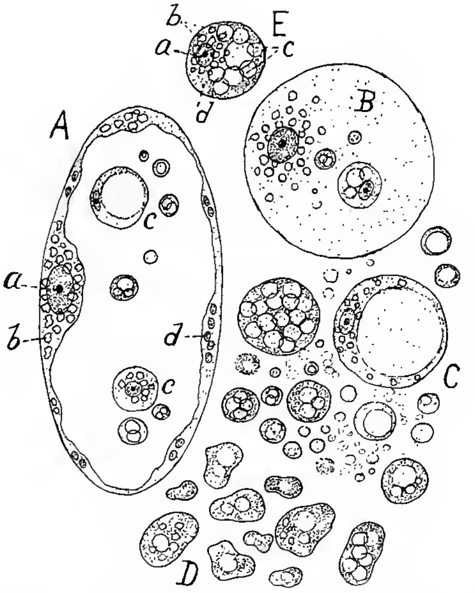

FIG. 1.—Different forms of sphærocytes from the mucilaginous tissue of tomato seeds. A, a fully matured sphærocyte cell (Gliding cell); a, nucleus with nucleolus; b, reddish brown coloring granules; c, intra-cellular sphærocytes; d, chlorophyll granules. B, sphærocyte nearly mature, showing several endo-sphærocytes. C, sphærocytes in various stages of development. D, amebo-sphærocytes of the ripe tomato. E, a mature nucleo-sphærocyte; a, nucleus with nucleolus; b, reddish brown coloring particles; c, vacuoles; d, granular cell-plasm.

Several types or forms of sphærocytes may be recognized, as

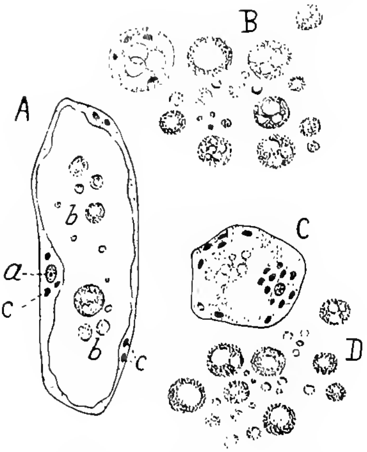

FIG. 2.—Sphærocytes of the grape. A, C, Mature pulp cells. B, D, sphærocytes in various stages of development.

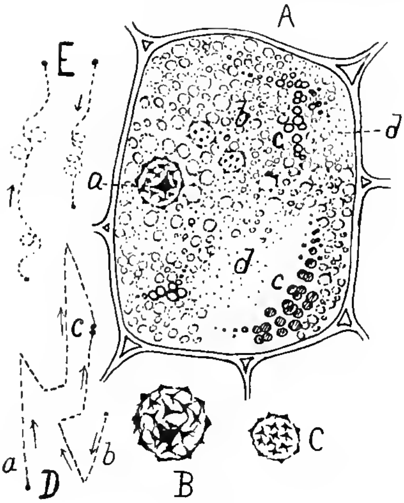

FIG. 3.

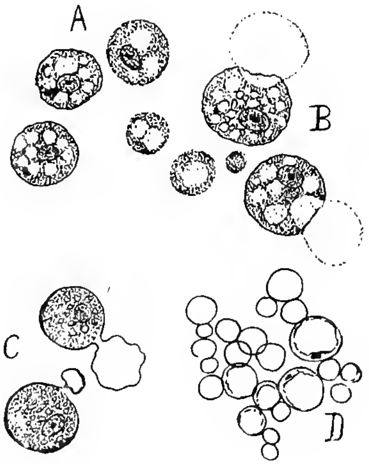

FIG. 4.

FIG. 3.—Sphærocytes of the pulp cells of the immature squash. A, pulp cell; a nucleus, with irregular branching nucleolus; b, sphærocytes in various stages of development; c, starch granules; d, plasmic granules, some of which are capable of very active movement. B, nucleus enlarged, showing irregular and branching nucleolus and outer irregular branching particles. C, a sphærocyte more highly magnified, showing outer irregular branching particles resembling those of the nucleus. D, illustrating motion of two plasmic granules (a, b), which meet at (c), where they come to rest. E, illustrating a more complex form of motion of plasmic granules.

Fig. 3 × 1000; D and E represent the directions and distances traveled by four different plasmic granules within a period of about 5 seconds, going at a speed of from 3 to 8 microns per second. At that rate the plasmic granule travels from 0.18 to 0.48 millimeters in one minute.

FIG. 4.—Nucleo-sphærocytes from hanging drop, twelve days old. A, living nucleated sphærocytes. B, dying sphærocytes showing extruding vacuoles. C, septation (?) as observed in hanging drop. D, a group of dead sphærocytes in hanging drop.

leuco-sphærocytes (bearing plasmic granules and vacuoles only), amebosphærocytes (showing ameboid mation), amylo-sphærocytes (bearing amylo-plastids and starch granules), chromo-sphærocytes (bearing chromo-plastids and other coloring particles), chloro-sphærocytes (bearing chlorophyll granules), and nucleo-sphærocytes (bearing one or more nuclei, but always without nucleoli). Of these the nucleo-sphærocytes are possessed of remarkable vitality, surviving all of the other plasmic cell constituents, inclusive of the other forms of sphærocytes. It would appear that the several form types of sphærocytes first mentioned are mere preliminary stages in the development of the nucleo-sphærocytes and of mature tissue cells. The nucleo-sphærocytes have been kept alive in hanging drop cultures for over eighteen months, undergoing increase in size and developing many nuclei. The indications are that the numerical increase of sphærocytes is from the cell plasm, rather than through septation, and begins to take place with the ripening changes of the fruit and continues until the decomposition changes, due to micro-organisms, begin.

2. Enteric Food Decomposition. Auto Intoxication. Food Anaphylaxis

Food Sickness.—The chief bacterial organisms concerned in protein digestion, are the *Bacillus subtilis* group, the *Bacillus coli* group and the *Bacillus pro'eus* group. In a carbohydrate diet, lactic acid formers play a very important part. Under normal conditions these several kinds of bacteria do not give rise to intoxications. However, if the diet is illy balanced, either a prolonged and excessive use of proteins, or, on the other hand, a deficiency in corbohydrates, the result is likely to be an array of intestinal and concomitant systemic disturbances and more or less marked toxic manifestations. It is known that the great quantity of *B. coli* normally present in the intestinal tract, does not cause trouble if the diet is well-balanced. If, however, carbohydrates are omitted for a time, with a full supply of proteins, autointoxication may follow. It is known that the colon bacillus grown in a dextrose medium, becomes an acid former without toxin formation. Sugars, especially lactose, are essential to the normal functioning of the intestinal bacteria. There has been much speculation and much discussion as to the true function of the intestinal bacteria. Without reviewing the entire situation, we may summarize the subject as follows.

1. The intestinal bacteria belong to two great groups: The protein digesters, and the carbohydrate digesters.

2. In the herbivora, which group of animals have a comparatively long intestinal tract, the carbohydrate (starch, sugar, cellulose) digesters represented by the *B. coli* group, predominate, and these organisms are present in enormous numbers. Should an attempt be made to feed such animals largely on proteids, the coli group of bacteria would develop toxins and the animals would soon die of auto-intoxication.

3. In the carnivorous group of animals the protein digesters predominate. The attempt to feed them largely or wholly on a carbohydrate diet (starches, sugars, cellulose and exclusive of fats) would result in death from malnutrition and starvation. There are not a sufficient number of carbohydrate digesters present to render such food available and, furthermore, the shortness of the intestinal tract and the more pronounced intestinal peristalsis in these animals, would not permit any considerable carbohydrate digestion to take place, even should the requisite bacteria be present. It is generally admitted that as far as herbivora are concerned, intestinal bacteria are essential, for without such bacteria these animals would be unable to digest cellulose, the principal food element derived from the plant cells. The significance of the intestinal bacteria in the carnivora is as yet not fully understood.

4. In the omnivorous group of animals, of which man and the domestic hog, are types, both groups of bacterial digesters are present in the digestive tract. The carbohydrate digesters are however by far the more important. That is, man would fare better, or would survive longer, with a purely carbohydrate diet (starches, sugars, fats, oil), than he would on a purely protein diet. The claims of the vegetarians are based upon this observation. The arguments of the vegetarians have much justification in fact, for the simple reason that most vegetable foods contain some proteins. However, to presume that we require no proteins would be absurd, and we certainly have ample proof that we require carbohydrates. The newborn infant requires both proteins and carbohydrates, the former to a dominant degree. The mother's milk contains both kinds of foods properly balanced. The growing child requires both kinds of foods in a somewhat different proportion. The adult requires both kinds of foods in yet different proportions, and so on throughout the entire life period.

In addition to the bacteria which may be looked upon as being normal to the intestinal tract of man and of lower animals, there are many organisms introduced with the ingested foods which may multiply, often in great numbers, and modify the digestive processes.

Yeast and sarcina groups may appear in the stomach, these organisms being adaptable to the acid medium. A vast array of extraneous bacteria, yeasts and protozoa, make their appearance in the small intestine and even a greater variety will appear in the large intestine. Some of these introduced micro-organisms are decidedly pathogenic or toxigenic, while others are harmful only under special conditions, and yet others appear to be without any special effect. In fact, the socalled normal intestinal bacteria and protozoa, are all of extraneous origin. Originally the relationship between these intruders and the host was undoubtedly antagonistic or parasitic, but after a long period of time the evolutional changes developed a truly beneficent relationship (mutualistic symbiosis). No doubt, in time, other beneficent micro-organisms will be added to those which already exist in the intestinal tract.

As long as the normal intestinal bacteria remain within the intestinal tract they are not pathogenic, but if introduced into tissues and into other organs, they may do great mischief. Within the peritoneum they set up severe inflammations. They may develop abscesses in the eye, ear, in the skin, in the liver, etc.

Occasionally ingested food may undergo toxic decomposition changes, giving rise to more or less severe symptoms. This is more likely to occur in corpulent elderly persons of sedentary habits and whose bowels are sluggish. The cases of authentic auto-intoxication are, however, comparatively rare and need cause little concern to the army nutrition expert. It is quite probable that many of the reported cases of enteric food autolysis or auto-intoxication were in reality due to the ingestion of bacterially decomposed and otherwise spoiled food.

The condition of anaphylactic (allergic) reaction to sera, to certain animals (horse, cat, dog, rabbit, etc.), to pollen (some forms of asthma, hay fever), to bacteria (in asthma, diseases), and to foods and drugs, is well-known, though scientifically not clearly understood. Attention has been drawn to these conditions from time to time when it was observed that the parenteral administration (*via* hypodermic, endermic, intra-muscular, intravenous injections; or perhaps *via* the abnormally permeable mucosa of the respiratory or alimentary tract) of certain proteins, resulted in a variety of unusual and unexpected symptoms, as itching, skin eruptions, lachrymation, enteritis, asthmatic manifestations, muscular pains, joint pains, difficulty of breathing, cyanosis, etc.; and very rarely (about 1 case in 50,000), prompt collapse and death. It is presumed that we are ordinarily not sensitive (anaphylactic) to the proteins with which we come in parenteral contact, but occasionally we ingest food substances toward which we have become artificially or naturally sensitive and some of the untoward symptoms referred to develop. The subject is certainly of sufficient importance to receive earnest consideration. Anaphylactic reactions to foods are sufficiently common to be worthy of consideration on the part of physicians and dietitians. There are already on the market a long list of prepared food proteins with which to make skin reactions tests for the purpose of determining the specific food substance toward which the patient is sensitive. Such skin reaction tests are simple and easily made, being similar to the von Pirquet skin test for tuberculosis. The skin abrasion (on flexor side of the forearm) is made by means of a small scalpel or a von Pirquet borer, and a droplet of the protein solution to be tested, is rubbed or instilled into the abrasion. The reaction, if any, develops in from five to thirty minutes and usually disappears again within a short period. The reaction is usually indicated by reddening, slight swelling or œdema, perhaps blistering, etc. The foods most commonly responsible for allergic reactions and skin diseases, especially among children and young people, are—egg albumin, wheat, rye, milk, cream, beef, strawberries, oat, tomato, fish and roe, almond, pork, buckwheat, and oysters. Asthmatic conditions may be produced by the foods named and others, further, by pollen, horse dander, cat hair, dog hair, rabbit hair, by staphylococci and streptococci, and perhaps by other organic substances. Skin tests should be made upon the men suspected of being anaphylactically sensitive to certain foods.

3. Molecular Food Decompositions

All organic substances undergo gradual molecular disintegration, without the presence of micro-organisms. Fats decompose into fatty acids and glycerin. Muscular tissues gradually become soft and friable, losing their elasticity. Vegetables undergo a similar change.

(*a*) **Ripe and Overripe Fruits.**—Apples and other fruits frequently undergo quite marked decomposition accompanied by discoloration and marked softening. To the unaided eye the changes present the characteristics of mold and bacterial decomposition. Careful microscopic examination will, however, show the total absence of organisms. The changes are in all probability enzymatic and are little understood, but it is advisable to place such altered food products in the class with those that are bacterially decomposed. Such decompositions are of infrequent occurrence, comparatively.

(*b*) **Ageing, Ripening and Storage Changes in Foods.**—The non-infection changes which take place in long stored foods, as meats in cold storage, dried meats, smoked meats, canned foods, etc., are essentially molecular in character. As a rule the socalled ripening changes which cold storage meats undergo, are considered desirable and are said to improve the flavor of the meat. Since most foods when placed in cold storage (meats, eggs) are bacterially infected, the purely non-infectious disintegrations, are soon exceeded by the decomposition changes due to bacteria and molds and it is only a matter of time when these decomposition changes will have advanced sufficiently to render such foods unsuitable for human consumption. Furthermore, the cold storage temperature, while checking the growth of the purely rotting bacteria, does not have an equal checking influence upon some of the low temperature toxin formers, and as a result we find occasional cases of poisoning from eating such foods, especially if inadequately cooked. It is generally known that cold storage foods spoil (rot, decay) very quickly when taken out of storage and exposed to ordinary temperatures. This is due to the fact that the marked rise in temperature encourages the rapid multiplication of the rotting bacteria which increased slowly during cold storage. Over-stored meats and also other foods, have a flat taste and otherwise defective flavor due to the chemical changes induced by the low temperature organisms present. Broken frozen eggs and storage eggs are usually bad, for several reasons. In the first place, low grade eggs are generally used; secondly, eggs, especially the yolk, constitute an ideal food for various bacteria, and even at the cold storage temperature there is a fairly rapid multiplication of bacteria.

(*c*) **Frozen and Thawed Foods. Abiosis.**—Freezing, followed by thawing produces a very marked chemical, mechanical, and molecular changes in foods, especially in foods of vegetable origin. Meats generally, inclusive of fish, shell-fish and oysters, suffer little in food value and in flavor through such changes. Thawed vegetables soon undergo marked chemical changes and are usually so vitiated in taste and flavor as to render them practically unusable as food. Thawed potatoes are wholly unfit for consumption. Frozen apples soon turn dark after thawing out and the sugar changes to alcohol. Thawed foods of all kinds are readily attacked by bacteria and molds, causing prompt decay. Frozen vegetables and fruits which are placed to cook without first thawing, suffer comparatively little in flavor and in food value.

Abiosis is a form of suspended animation due to freezing. Certain animals may be completely frozen, with apparent complete suspension of all life functions, and on careful thawing out will again be restored to life. This discovery has recently been made use of commercially. The Pictet procedure as applied to fish is carried out as follows. The fish in a tank of water are supplied with oxygen which is admitted to the water and which permits the drawing off of most of the water, whereupon the vessel packed with the fish, is run into a refrigerating tank and the entire mass (of water and fish) frozen into one solid block. This block, with suitable covering to prevent thawing, may now be shipped to any desired place. Upon arrival at the destination, the frozen block is put through a slow thawing process, lasting for about ten hours, whereupon the fish again assume their normal activities when placed in a suitable water supply. This method for shipping live fish is said to be simple and cheap. It is asserted that the state of abiosis through freezing has been induced in animals much higher in the scale of evolution than fish, as sheep and dogs; however, no practical application has as yet suggested itself in these cases.

4. Fermented Products

As already suggested, all fermentation or enzymatic changes in food materials of all kinds are catabolic or destructive. It therefore follows as a natural corollary, that fermented food substances have a lesser food value than before they underwent such changes. The only excuses for using fermented foods are that the process produces marked changes in taste and flavor which changes are generally considered pleasing and desirable. Fermentation may also improve the keeping qualities of foods. In rarer instances there is a decided improvement in the food value of the fermented article, as in Sauerkraut. In many instances the enzymatic changes render the food substance more readily digestible.

(*a*) **Cheeses of All Kinds.**—Cheeses are made from milk coagulated by rennet; the coagulum freed of the whey is pressed into cakes and then ripened by certain organisms, largely bacteria and molds, with incidental yeasts, and other infecting organisms, as skippers, hoppers, mites, etc. The ripening (fermenting) processes are more or less regulated and are time honored.

Cheeses made from clean wholesome milk are not objectionable but to ascribe to cheese any special nutrient value is probably incorrect. Eating cheese occasionally, in small quantities, certainly does no appreciable harm. On the other hand, poisoning from cheese is fairly common (tyrotoxism), probably due to a variety of incidental and accidental contaminants, belonging to the bacteria, yeast and mold groups. Since most cheeses are quite perishable and likely to undergo secondary toxic decomposition, they should not be used at all as an army food, or only sparingly and occasionally, and in the comparatively fresh state.

(*b*) **Sauerkraut and Similar Products.**—Sauerkraut has comparatively little food value, but it forms excellent roughage and checks auto-intoxication through regulatory influences upon the bacterial flora of the intestinal tract. Although Sauerkraut may become infected with objectionable bacteria, yeasts and mold. this is comparatively rare, and such spoilage is easily detected by the changes in odor, taste, flavor and color. The acid present effectively checks the development of the usual rotting bacteria and of most pathogenic bacteria.

(*c*) **Sour Milk.**—Clean wholesome milk fermented by the lactic acid organisms normal to milk, forms a most excellent food, of special value as a regulator of the bacterial activity of the intestinal tract. It assists materially in preventing intestinal intoxications and putrefactive fermentations, which are believed to hasten the senile cell and tissue changes and arteriosclerosis.

There are a number of strains or varieties of the *Bacillus acidi lactici*, the normal or natural milk souring organism. It should be borne in mind that there are many other organisms which will cause the souring of milk and there are some investigators who declare that the sour milks are all equally good, no matter what the acid former may be. This is not only a dangerous doctrine but is furthermore not in accord with fact. Milk soured by the *Bacillus coli* is not to be recommended as an article of diet.

Sour fermented milks may be divided into two groups, those naturally fermented and those which are artificially fermented. The principal soured milks are yoghurt, kephir, koumiss, matzoon and leban, prepared in different countries. The artificially soured milks are prepared by adding pure cultures of one or the other strain or variety of the lactic acid organism. The native or natural milk fermenters (as "kephir granules" or "seeds") usually represent a mixed infection, consisting of bacteria, yeasts and some mold.

Sour milk is far superior to Sauerkraut as an article of diet, is fully equal to it as a preventer of intestinal fermentation but contains far less roughage. Sour milk is very useful in some intestinal disorders, in indigestion, and in typhoid fever.

(*d*) **Irregularly Fermented Products. Semi-silage.**—Cheese, Sauerkraut and sour milks, are more or less regularly fermented; that is the fermentation processes for each article are more or less controlled, quite uniform, subject to but little variation, and are time honored. As has already been indicated, the fermented and ripened food substances, as cheese, soja sauce, Sauerkraut, sour milk with its modifications as yoghurt, koumiss, matzoon, etc., are not by any means stable products. Unless kept under certain conditions (cool, dry air, away from contamination), they rapidly undergo secondary decomposition changes, due to the invasion of other molds, yeasts, bacteria, mites, insect larvæ, etc., resulting in the complete deterioration of the products, rendering them wholly unsuitable for consumption.

There are certain food substances which undergo an irregular fermentation, irregular in the sense that the fermentation is not regulated or controlled by the processes and the preliminary preparations to which the food product is subjected. A most notable example of this kind is tomato paste. The manner of preparing this substance is extremely variable, and as a result there is an extremely varied bacterial and other infection. A lot from one manufacturer may have a peculiar fruity aroma due to certain yeasts; another a bad sour odor; others a moldy odor; still other lots avery disagreeable silage odor. The usual process of manufacture encourages or permits a form of decomposition akin to that which takes place in green siloing.

The manner of preparing plug chewing tobacco, encourages a subdued fermentation (molds, yeasts and bacteria) which likewise is akin to siloing. The throat and mouth infections and irritations so frequently complained of by tobacco chewers, are no doubt traceable to the contaminating organisms in the chewing tobacco, rather than to the nicotine.

It is strongly advised not to use substances which are irregularly fermented. It is true that tomato paste is, as a rule, not taken into the digestive tract until thoroughly heated, as in soups and sauces. However, ptomaines or toxins may be present, giving rise to fatal poisoning, even after the article is cooked. "Limber neck" (botulism) in ducks has resulted through feeding them tomato paste.

(*e*) **Sauces. Relishes.**—If made from wholesome vegetables, good vinegars, pure spices, etc., there is no objection to the use of relishes and sauces as stimulators of the appetite and as improvers of the flavor and taste of foods. They are, however, not to be considered as dietary essentials, and they do tend to encourage overeating. Often more or less defective and spoilt vegetables, bad vinegar, cheap sugar, etc., are used in relishes, resulting in a high spore, yeast and mold count. Such defects are usually more or less masked by the high spicing which is employed. Some of the relishes are partially fermented and not infrequently relishes are found on the market which are quite badly decomposed.

(*f*) **Chewing Tobacco.**—As already indicated, the very manner of preparing chewing tobacco (plug tobacco, twist, and inclusive of cut plug tobacco) encourages a modified form of siloing, ripening or fermentation, often giving rise to special or peculiar flavors and aromas. Yeast development is encouraged by the syrup used but the reduced moisture checks active growth. The moisture is, however, sufficient to encourage a subdued development of certain molds, and the bacteria present are perhaps essentially symbionts of both yeasts and molds.

The principal objections to the use of chewing tobacco, in addition to the toxic effects due to the nicotin present, and because of which the use of all kinds of tobacco is harmful, are:

(*a*) Throat and mouth infections, no doubt traceable to the contaminants (bacteria, molds, and perhaps also yeasts) present.

(*b*) Tobacco chewing results in increased expectoration of saliva, and is therefore, a drain on the salivary glands.

(*c*) The habit of borrowing a chew often results in the transmission of infections, as staphylococcic, streptococcic, pneumonic, catarrhal, gonococcic and syphilitic.

It must be borne in mind that tobacco (no matter what the form of its use) does not in any way prevent or retard disease invasion. Tobacco users claim that the weed keeps them free from disease. This is wholly false. In fact, the drain on the salivary glands interferes with digestion and encourages infection.

II. THE PRINCIPAL GROUPS OF ORGANISMS CONCERNED IN FOOD SPOILAGE

The food micro-analyst need concern himself but little about the kind of food contamination, for as has already been indicated, all infections and contaminations are harmful, if they exceed certain maximum limits, which limits will be given in a later chapter. It is, however, well to discuss very briefly the principal groups of organisms concerned in food spoilage, taking them up approximately in the order of their importance.

1. The *Bacillus botulinus* Group and Symbionts. Botulism

The *Batcillus boulinus*, commonly known as the sausage bacillus, because first observed and studied in connection with fatal poisoning from sausages, is a toxigenic, sporogenous, non-parasitic, rather polymorphic, fairly large bacillus, existing in symbiosis with other organisms (aerobic bacteria and perhaps also yeasts), under more or less anaerobic conditions. The toxin which it forms is highly virulent and is said to be destroyed by heating to 80°C., and the spores which are unusually susceptible to heat, are also destroyed at a temperature of 80° C. It manifests no parasitic tendencies and does not multiply within the living tissues of either plants or animals.

Recently much has been said and written about botulism, or poisoning from foods which contain the *Bacillus botulinus*, or which contain the toxins formed by this bacillus. There are some observers who claim that there is nothing to the subject of botulism; that pure cultures of this bacillus have been injected into experimental animals and also extracts of such cultures; without harmful results. These observers have evidently entirely overlooked the fact that the *Bacillus botulinus* is toxic only when developing in symbiosis with certain other organisms (aerobic bacteria of various kinds and perhaps also certain yeasts). The aerobes not only use up the free atmospheric oxygen thus rendering the conditions suitable for the growth and multiplication of the *B. botulinus*, but the chemical changes induced in the food substances by the aerobes result in the formation of highly potent toxins, elaborated either within the botulism organism or in the food substances upon which this organism feeds.

It is a fact that there have been numerous cases of food poisoning presenting the symptoms characteristic of botulism and yet the most careful bacteriological and microscopical examination failed to disclose any considerable number of organisms which could be definitely recognized as the *B. botulinus.* It must, however, be borne in mind that a comparatively small number of this organism will suffice to produce enough toxin to give rise to fatal poisoning.

The sausage bacillus is evidently widely distributed and is not by any means limited to sausages and sausage meats as was at first supposed. This bacillus has been found in other meats, in fish, in shellfish, in crustaceans, in milk, in eggs, and in a variety of vegetable substances, as canned string beans, in tomato products, in asparagus, in silage, especially green alfalfa silage, and in cereals. Dixon declares that canned vegetables put up by the cold process may contain the *B. botulinus.*

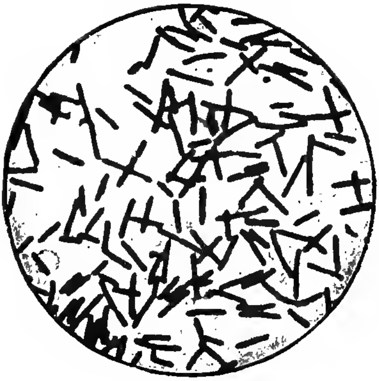

FIG. 5.

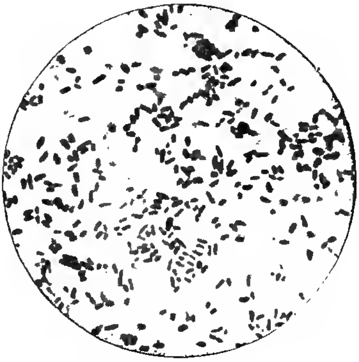

FIG. 6.

FIG. 5.—*Bacillus botulinus* from a sugar-gelatin culture.—(*Pittifield, after Kolle and Wassermann.*)

FIG. 6.—*Bacillus enteritidis.* Under this name is included a number of organisms of the Gaertner group which play a very important part in meat decomposition and meat poisoning. It is also known as the dysentery group. The organisms are actively motile, non-sporogenous, aerobic, non-liquefying and Gram negative.—(*Jordan after Kolle and Wassermann.*)

The bacillus is apparently quite polymorphic and the spore formation is irregular. It is suggested that all foods which contain some irregularly formed, fairly large, motionless or slightly motile bacilli, with irregularly elliptical to somewhat spindling, fairly large endospores (causing appreciable bulging of the cell), associated with a considerable number of other bacteria, cocci and yeasts, and giving off a valerian-like or butyric acid odor, be looked upon with suspicion. It is possible to mistake the tetanus bacillus and the hay bacillus for the sausage bacillus. The fact of the wide range and distribution of this bacillus, coupled with its symbiotic habits, should lead us to look with suspicion upon all food substances (especially bulk foods) that contain any considerable number and variety of aerobic bacteria, even though there may be no satisfactory evidence of the actual presence of the sausage bacillus. It is also quite evident that the sausage bacillus has been blamed for food poisonings which were caused by other organisms. This is more especially the case in food poisoning among the herbivora.

The food microanalyst is not expected to determine the presence of the sausage bacillus in foods. The microscope may reveal the presence of more or less irregular rather large bacilli (1.5 microns by 5 to 8 microns), showing occassional rather irregular (somewhat triangular) endospores; but such findings do not warrant the conclusion that it is the *B. botulinus*. It is advised to make feeding tests (young rabbits, white mice, guinea pigs, cats, dogs, chickens, ducks) of all foods showing any considerable number of rod shaped bacteria with endospore formation, in order to prove or disprove the presence of toxins.

2. The Group of Filth Bacteria

Dirt has been defined as matter out of place. Filth is objectionable matter out of place and filth bacteria are all traceable to objectionable matter out of place. The average dish rag as used in washing dishes, is loaded with bacteria, in part derived from food remnants in dirty dishes, but more especially with organisms that develop in the damp cloth during the intervals between dish washings. A long used handkerchief is loaded with bacteria from fingers, from face, from mouth from nasal passages, from respiratory tract, and those which multiply in the cloth during its stay in the pocket. The handkerchief is often stained and discolored from nose and mouth secretions, usually giving off a very disagreeable odor, designated as mucus. This mucus odor is especially pronounced in the presence of a considerable number of the *Bacillus catarrhalis* and of the coccus and diplococcus forms.

There is no distinctly recognizable group of filth bacteria. However, we may recognize small bacilli (resembling the colon bacillus), small but distinctively diplobacillus forms, and several different kinds of coccus forms, as filth organisms. For example, tomatoes put up in unsanitary canneries, usually show a considerable number of these three types of microbes, traceable to filthy tomato lug boxes, filthy washing machines, filthy carrier belts, filthy vats and dirty hands of workers. In some canneries the toilet provisions are entirely inadequate and the workers, men and women, simply wash their hands in the tomatoes. Workers have been seen to deliberately expectorate into the tomato containers. Flies and insect remnants are frequently found in the finished tomato product.

Bread is often highly contaminated (usually in streaks and in certain loaves) due to fragments and scrapings of deposits in and upon dirty mixing machines. The highly unsanitary method of handling bread open, without covering of any kind, leaves dirt and contamination from filthy hands, filthy containers, air blown animal excreta, etc., upon the exterior of the bread. The filth contaminations of milk are familiar to all.

3. The *Bacillus coli* Group

This bacillus, in one or more of its many forms, is normally present in the intestinal tract of man and of the lower animals and is especially abundant in the intestinal tract of the herbivora. The wide distribution of this organism is known to all bacteriologists. The presumptive quantitative colon bacillus test is a routine in all food laboratories and positive results are quite generally admitted as evidence of sewage contamination. The test is too well-known to require description and the micro-analyst should make it when thought desirable, as for example in connection with water analysis, milk analysis, oyster analysis, etc.

In field practice an incubator for making the presumptive *Bacillus coli* test, may not always be available. The following vital incubation may then be substituted. In place of test tubes use pieces of very thin rubber tubing, cut to give a capacity of 10 cc., close one end by tying with stout twine, well knotted, or by means of a clip fastener. Into this place 5 cc. of the ox-gall medium, add 1 cc. (more or less as may be desired) of the liquid to be tested, close this end like the other, mix by shaking. Prepare from three to five other tubes in a similar manner, as may be indicated. Place these tubes in the incubator box of heavy aluminum (4 in. × 4 in. × 1 in., with lid, fastening strap, and rings) and fasten this so as to be held in place immediately upon the undergarment next to the skin, on left side of body. The box is held in place by a band over the right shoulder (narrow bandages are excellent) and another band around the waist. The box must be constantly worn for from 36 to 48 hour. In the night time, the box may be shifted forward, to rest upon the abdomen.

If the opportunity presents itself, animals (as horse, dog, rabbit) may be used to furnish the incubation temperature. Gas formation is observed by the swelling of the inoculated incubated rubber tubes. The contents should also be tested as to odor. The rubber tubes may be cleaned, sterilized and re-used.

4. The *Bacillus enteritidis* Group

This bacillus is the principal organism responsible for meat poisoning. It looks like the colon bacillus, is more actively motile, ferments dextrose but not lactose and does not coagulate milk. The poison which it forms is not destroyed by boiling.

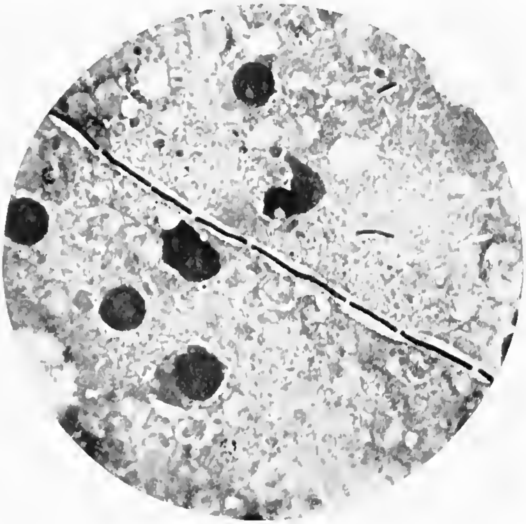

FIG. 7.—*Bacillus welchii*, also known as *B. aerogenes capsulatus* and *B. phlegmones emphysematosæ* in smear preparation. This is the common "gas bacillus," because of the abundant gas formation in the tissues invaded and in culture media. It is a plump large nonmotile, anaerobic, capsulated, Gram positive, spore-bearing bacillus and is very widely distributed in nature.—(*Williams*.)

In field routine it is not practicable to determine the identity of the organisms responsible for meat poisoning. The analyst should keep in mind that some animal products, as caviar (Sturgeon) and the roe of several other kinds of fish, may be poisonous and that oysters and shellfish generally, decompose or spoil very readily; that fish of all kinds spoil readily and that all meat pastes, minced meats of all kinds, sausage meats and all long stored and long pickled bulk meats, as hams, bacon, shoulders, etc., are to be looked upon with suspicion. Feeding tests on animals (dogs, chickens, cats, guinea pigs) may be made to determine the possible presence of poisons.

The general symptoms of *B. enteritidis* poisoning are referable to disturbances of the digestive tract, as vomiting, gastric pain, diarrhea; thus differing essentially from *B. botulinus* poisoning.

5. The *Bacillus dysenteriæ* Group

There is much that is not cleared up about this bacillus, discovered by Shiga. It resembles the colon group in appearance but is said to be non-motile, does not liquefy gelatine, does not form gas with sugars, does not form indol, and is agglutinated by the blood of patients suffering from bacillary dysentery. It forms a toxin. It shows a very intimate functional relationship to several other bacilli, as the Flexner bacillus (bacillus of paradysentery or pseudo-dysentery), the typhoid bacillus, the paratyphoid bacillus and the toxic forms of the colon bacillus.

The dysentery group is very widely distributed in the intestinal tract of various animals, in filth, in sewage, in water supplies, in filthy food substances, on the person, on hands, in finger nail deposits. Its distribution is nearly as wide as that of the colon bacillus. The housefly is the most common carrier and distributor of this infection. It is essentially a filth organism and does not survive long under cleanly surroundings.

Dysentery has long been known as the forerunner of typhoid, and of cholera in cholera districts. The food analyst need not concern himself especially with tests for this organism, as giving proper heed to the presumptive colon bacillus test also safeguards against the dysentery group. It may occasionally be desirable to examine the stools of dysentery patients in order to diagnose between the bacillary and amebic forms of this disease.

The essentials to be borne in mind are:

(*a*) *Bacillus coli*, in excess, in foods and drink, is often the forerunner of bacillary dysentery.

(*b*) Bacillary dysentery is often the forerunner of typhoid.

(*c*) Therefore heed must be given to the colon bacillus test. In these regards there must be a close relationship between food inspection and analysis, and personal and camp sanitation and hygiene. This cannot be too strongly emphasized.

6. The Group of Rotting Bacteria

Rotting bacteria are found wherever higher life exists. These organisms cause the decomposition of all plants and animals after life has become extinct. They usually give rise to foul, putrid odors and cause a rapid disintegration of cells and tissues, due to enzymatic action. Some rotting changes are, however, not accompanied by bad odors, nor do all rotting bacteria form toxins or ptomaines. A putrid odor is unmistakable evidence of decomposition, but the absence of bad odor is not always proof that there is no decomposition. Fish may have a normal fish odor and yet be well advanced in decomposition. In fact, a marked fish odor is as a rule evidence that the decomposition changes due to rotting bacteria have already set in. A flat, faint or insipid flavor is, as a rule, evidence of progressive decomposition. Again, the principal evidence of initial decomposition may be a more or less marked change in color, as darkening, mottling, reddening, unusual paleness, etc.

The tests for decomposition bacteria are entirely quantitative and all bacteria found in foods are to be considered as belonging to this class. All foods that contain an excess of bacteria are to be rejected. The permissible maximum limits will be given in Chapter IX.

7. The Group of Silage Bacteria

Rotting bacteria are primarily aërobic, that is they require a free supply of atmospheric oxygen. If the environment is so changed as to reduce the free oxygen supply, the acid former or silage bacteria gain the ascendency. The silo is a large container filled with vegetable matter. The rotting bacteria which may be present are soon overcome by the lactic acid bacteria. Of course not all food substances may be successfully siloed. The silage bacteria are of incidental interest only. They have already been referred to in connection with chewing tobacco and tomato pastes. In so far as they are found in unfermented foods intended for human consumption, silage bacteria are to be considered as rotting bacteria and no attempt need be made to differentiate between rotting bacteria and silage bacteria.

8. The Streptococcus Group

Streptococci occur in milk, in cream, in sewage, in filth, and in many contaminated foods, they often appear in the finger nail deposits. Some are supposedly harmless while others are pathogenic. True streptococci should always be looked upon with suspicion, if they occur in food materials. It is sometimes not easy to distinguish between streptococci and streptobacilli. The *Streptobacillus acidi lactici* is by some described as a streptococcus, the individual cells being but slightly elongated. The comparatively long chains of

Streptococcus fecalis are apt to be abundant in sewage contaminated foods.

The streptos are easily recognized by the direct microscopical examination. The number of cells in a chain is variable, from three to ten and more, usually five to eight. Free single cells will be recognized as coccus forms. Groups of two will be recognized as diplococcus forms.

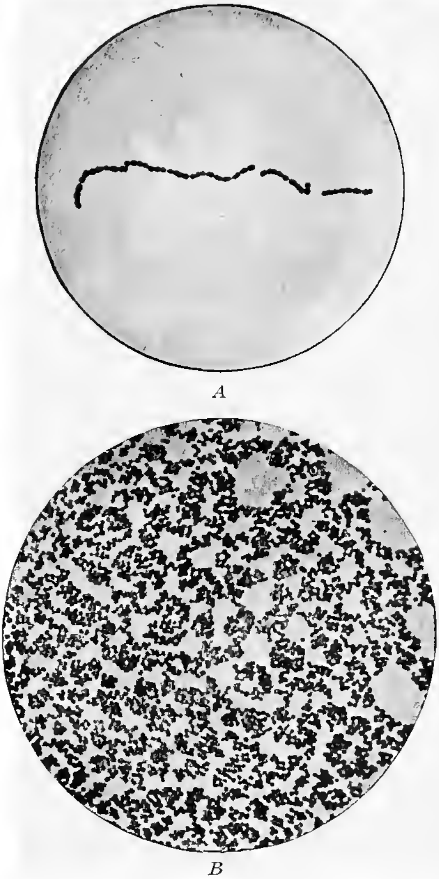

FIG. 8.—*Streptococcus* (*Staphylococcus*) *pyogenes* and *S. aureus*. There are three principal species of Streptococci (*S. pyogenes albus*, *S. pyogenes aureus* and *S. pyogenes citreus*), similar in form and appearance, concerned in pus formation, as in wound infection. These organisms are very widely distributed in soil and air.

Note the chain form arrangement of the cocci in *A*. *B* is a smear preparation.—(*Stitt* (*A*) *and Pittifield* (*B*).)

9. The Staphylococcus, Coccus and Diplococcus Forms

The true pus formers play a rather insignificant part in food analysis. They are, however, significant filth organisms and are of importance in sausage casings, sliced meats, in eggs and in canned milks (evaporated and condensed, sweetened and unsweetened) and also in gelatines. They occur abundantly in filth contaminated foods.

Coccus forms may be confused with protein granules, with the larger plasmic granules (Plasomen, Mikrosomen), with cholesterin particles, with minute fat globules, with endospores and with the ultimate elements of disintegrated muscle fibrillæ. It is sometimes difficult to distinguish between very small mold spores and larger coccus forms. Sausage casings of sausages stored in damp places, are generally coated with a slimy or smeary layer of large cells representing coccus and diplococcus forms.

The experienced analyst, as a rule, has little difficulty in recognizing coccus forms of micro-organisms and they should be recorded either as coccus forms or diplococcus forms, or both, irrespective of species, and in the food rating, should be given the same value as rotting bacteria, and their presence may generally be construed as indicating filth contamination, though in some instances (sliced meats, sweetened condensed milk, eggs, gelatine, dried meats, sausages) they indicate special decomposition changes.

10. The Tetracoccus and Sarcina Groups

These have a very incidental significance in food analysis. They are occasionally found in milk, in sewage and in certain fermented foods. They are usually incidental to other more pronounced infections and decompositions and only occasionally will it be necessary to give them any special attention or a rating value or quality value in food analysis. They are, as a rule, readily recognized under the compound microscope as they are comparatively large and the cell-groupings are characteristic.

11. The Mold Group

These are so readily detected (by the hyphæ and also by the spores) and their presence in foods is so universally recognized as objectionable that they cause but little difficulty to the analyst. His chief concern is to acertain their presence in excess of the permissible amounts. Kinds or species of mold are immaterial, as all kinds are objectionable when present in excess (exceptions, mold ripened cheeses).

Molds are cosmopolitan, essentially aërobic, prefer slightly acid media and not too high a water content, though some thrive well in liquids. They are essentially surface growers, though the hyphæ (mycelium) will soon spread through the entire particle or mass of food. They are most common in and upon vegetable foods, though they also appear upon dried and smoked meats, as chipped and sliced beef, ham and bacon.

Rotting of apples, oranges, berries of all kinds, pumpkins, squashes, tomatoes, potatoes, etc. is generally due to molds. Mold will form on the top of jams and jellies in jars and in other containers. The *Penicillium glaucum* is found everywhere, on stale bread and pastry, on such acid fruits as the lemon, on preserves, jams, jellies, etc.

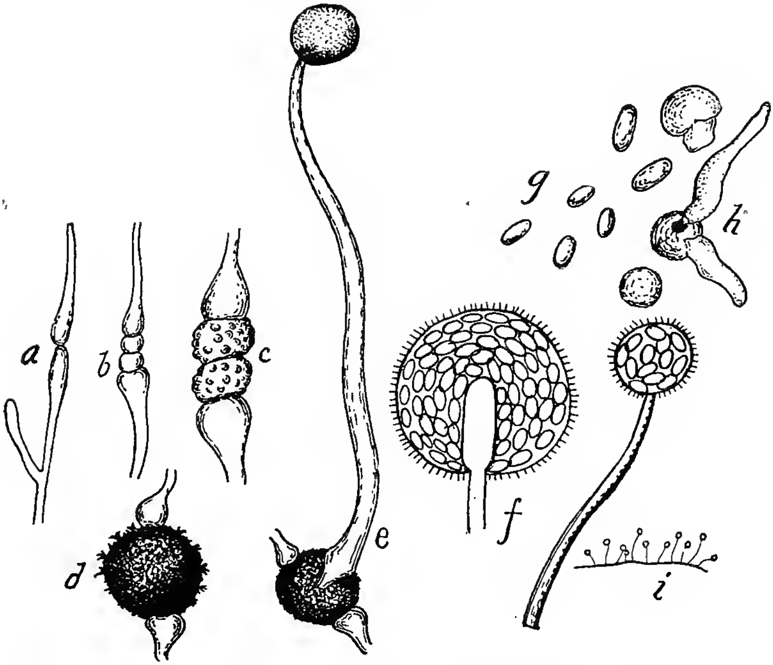

FIG. 9.—Development of *Mucor mucedo*. *a, b, c, d,* stages in the formation of the zygospore; *d,* mature zygospore; *e, f,* endospore formation; *g,* endospores; *h,* germinating spore, the beginning of the new zygospore forming cycle. The appearance of the stalks and the spore bearing capsules explains why this is called the "pin cushion fungus." Related molds occur on stale bread, on fruits, on damp gloves and leather generally. It is the cause of a fatal infectious disease in house flies.

The experienced microanalyst can readily distinguish between field mold and cannery mold thus being able to differentiate between food decomposition due to inadequate culling and decomposition changes occasioned by delays and defective methods at the cannery. The usual preservative added to food substances (0.10 benzoate) does not prevent the development of some molds. Spices of all kinds may show mold; also meals of all kinds, if stored in damp places.

Cereals, grains and nuts often show mold. Catsups, tomato pastes, fig paste, prunes and dried fruits are apt to show abundant mold.

12. The Yeast Group

Yeasts are of great importance in beer and wine making and in bread making. They are incidentally present in a great variety of food substances, especially in fruits, jams and jellies and all such substances as contain sugar and high water content. Most of the species are saprophytic though some are parasitic. Of the parasitic forms, some are obligates with a very limited host range. Thus *Nematospora Coryli* is parasitic on the fruit of the hazel; *N. Lycopersici* is parasitic on the fruit of the tomato. A toxigenic yeast has recently been discovered which is obligatively parasitic in the stomach of herbivorous animals (sheep, goat, rabbit, guinea pig). Other species cause skin diseases and yet others invade the lymphatics.

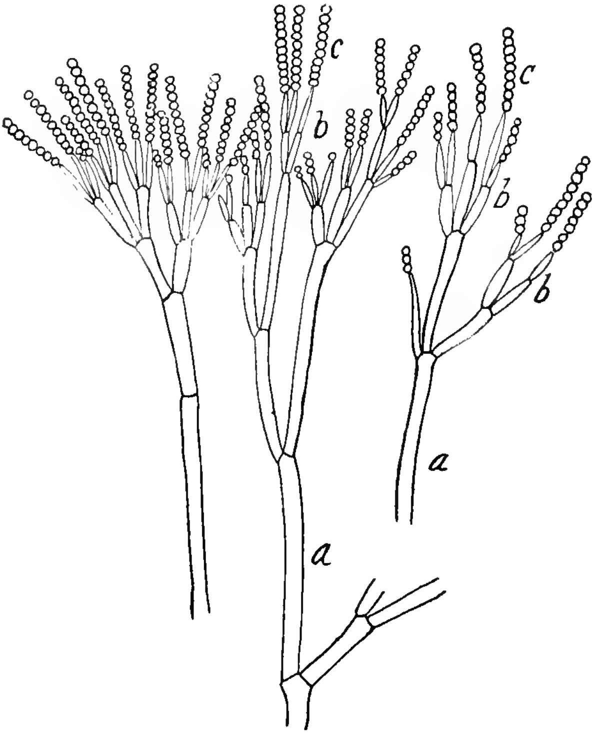

FIG. 10.—*Penicillium glaucum* showing the characteristic spore formation. This fungus is a true saprophyte, the common green mold, occurring on a great variety of organic substances.

Wild yeasts may invade fermented products causing deterioration in odor, flavor and taste (wines, beers, ales, saké). Some wild yeasts develop fruity flavors. Yeasts are comparatively rare in animal substance. Pickled pigs feet, minced meats, oysters, meat pastes and some soups and soup stocks, may show yeasts. Purely saprophytic yeasts may develop in the stomach of animals (herbivora) after death.

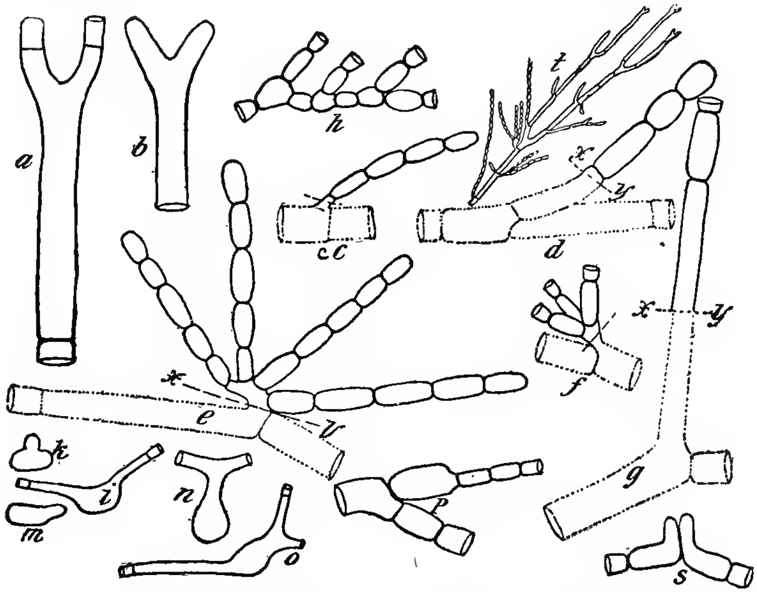

FIG. 11.—*Oidium lactis.* *a*, *b*, Dichotomous branching of growing hyphæ; *c*, *d*, *g*, simple chains of oidia breaking through subdtratum at dotted line *x–y*, dotted portions submerged; *e*, *f*, chains of oidia from a branching outgrowth of a submerged cell; *h*, branching chain of oidia; *k*, *l*, *m*, *n*, o, *p*, *s*, types of germination of oidia under varying conditions; *t*, diagram of a portion of a colony showing habit of *Oidium lactis* as seen in culture media.—(*From Bull.* 82, *Bur. Animal Industry, U. S. Dept. Agr.*)

III. SUBDUED AND RETARDED FOOD DECOMPOSITIONS

Under usual or ordinary conditions, all air exposed food substances undergo prompt rotting, decay or decomposition, due to various micro-organisms, belonging to the group of so-called rotting bacteria. This is the ultimate natural end of all plants and animals, These decomposition changes are, however, greatly modified (hastened, retarded, qualitatively or biologically altered, etc.) by a great variety of factors, such as warmth, light, cold, moisture, chemicals, etc. These modifying factors are also of the greatest importance in food microbiology and food decomposition, as has already been indicated.

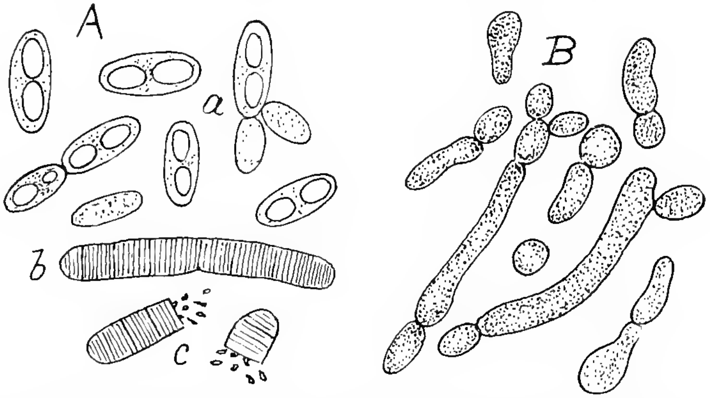

FIG. 12.—Parasitic Saccharomycetes. A, an obligate saccharomycetous parasite of herbivora (sheep, goats, rabbits, guinea pigs) which caused fatal sheep poisoning in San Francisco. The entire life cycle is completed in the stomach and intestinal tract of the animals; *a*, vegetative cells formed in the stomach; *b*, a spore bearing cell from the large intestine; *c*, ruptured spore sac liberating the very minute spores. B, Blastomyces (Saccharomyces) parasitic in the skin of cattle, sheep, guinea pigs, etc.

The biology of most of the retarded or partially suppressed food decompositions is little understood. Ravenel and others have given much attention to some of them. It is quite evident that symbioses, of perhaps complicated nature, play an important part in the life history of some of the toxigenic organismso, ccurring in those decomposition changes which are retarded and subdued by low temperatures, reduced free oxygen, etc.

In *subdued* decomposition, there is a change in the quality as well as in the quantity of disintegration, due to factors whose general tendency is to reduce and even to completely check the preponderant primary infection. Under *retarded* decompositions, a marked reduction in the usual or normal rate of microbic disintegration or decomposition is understood. The essential difference between subdued and retarded decomposition being, that in the former instance, the retarding factors do not come into play, until *after* the usual or normal decomposition changes are already well under way; whereas, in the second instance, the retarding factors have acted from the first. For example, in exposing badly contaminated cream to a freezing temperature, as in ice cream making, the major or dominant decomposition change is checked by the greatly lowered temperature; while placing fresh wholesome milk on ice, retards the usual or normal decomposition changes. While low temperature (10°C. to 0°C.) delays or checks the activity of all living contaminations of a food, the effects are not the same upon the different species and varieties of organisms which may be present. The development and activity of the rotting bacteria (saprogens) may be inhibited to a greater degree than that of some of the toxigens; and again the low temperature may completely alter the quality of the decomposition changes. Enzymatic action is altered, or may be almost totally inhibited, and an essentially harmless organism may become toxigenic or otherwise harmful.

1. Preserved Foods

As is known, the use of food preservatives does not by any means prevent all decomposition changes for all time. Preservatives are used to retard or hold back the usual invasion by the rotting or decomposition bacteria, for a time at least. By adding certain amounts of preservatives to fresh uncontaminated foods, it is possible to keep such foods wholesome and comparatively uncontaminated for a time. However, if the same amount of preservative is added to foods which are well advanced in decomposition, practically no reduction or retardation in decomposition is observable.

Adding preservatives, such as benzoate, formalin, boric acid, borax and hydrogen peroxide, to milk, interferes with the normal souring and encourages the development of organisms which give rise to disagreeable tastes, flavors, and odors. Molds develop quite actively in tomato catsup and in other vegetable products to which 0.10 per cent. of sodium benzoate has been added. Certain molds will develop in 10 to 15 per cent. alcohol. Certain yeasts and bacteria will develop in foods immersed in saturated salt solutions or packed in salt. Yeasts and molds will gradually develop in 40 to

50 per cent. sugar solutions. Molds, bacteria and yeasts, will develop in potent pharmaceuticals and in medicamenta with high water content. Smoked and dried meats of all kinds soon become mold infested upon the exterior and in time will also undergo bacterial decomposition. Sliced meats (salted, smoked, and dried) put up in glass jars are quite generally highly contaminated with various bacteria (largely coccus and bacillus forms).

The differential or selective action upon decomposition induced by variable quantities of a given chemical preservative added to a given food substance, or of a given quantity of the same preservative when added to different food substances, require further careful study. An almost endless series of interesting problems suggests itself. All that may be stated at the present time is, that the more common food preservatives, as usually employed, retard for a time the usual or normal decomposition changes and permit certain modified decompositions to take place, which may result in more or less harmful and objectionable changes in the food substance. The matter of special importance is to bear in mind that the preserved foods (desirable, necessary, or essential food preservation) should be used *before* the otherwise inevitable and usual decomposition changes shall have set in, and that the modified decompositions due to the presence of the preservatives, are generally more noxious and more objectionable than the normal or usual decompositions of a corresponding quantitative degree. Preserved foods are not necessarily harmless even though the preservatives added are harmless. Partially decomposed foods to which enough preservative is added to materially reduce and retard the initial or primary decomposition, are trebly harmful. First because of decomposition, which already exists; second, because of the large amount of preservative added; and, third, because of the more complex and usually toxic secondary decomposition changes initiated because of the added preservative.

2. Canned Foods

The canning of foods has now assumed gigantic proportions. The cannery methods have been greatly improved within recent years, and it may be stated that modern scientific canning leaves little to be desired. Most unfortunately, however, there are many engaged in the business of canning foods who fail to employ modern methods, either through ignorance or because of the effort and expense involved, or because they are wholly lacking in the sense of moral obligation. It may be stated that it is ignorance, rather than an unwillingness to make the required financial investment or the lack of moral sense, which is responsible for the majority of defective cannery methods. Whatever the real reason for the continued use of defective cannery methods may be, the fact remains that spoiled canned foods cause more illness and deaths than result from any other dietary cause or factor.

In the trade, the quality of canned goods is judged very largely by the external appearances of the cans (also designated as "tin"). This is unscientific and unsatisfactory. It is possible to fill cans with decomposed food and have the cans look all right externally. The following canned foods may be rejected without microscopical or chemical or other special testing.

Swells and Springers.—The claim has been made by some canners that overfilling will cause swelling of cans. This is not quite true, certainly not as far as the canning of ordinary food substances is concerned. A marked swell (bulging of both ends of a can) is quite generally evidence of decomposition changes within the food substances in the can. It usually, though not necessarily always, indicates active or more or less subdued or modified decomposition going on at the time, and such decomposition changes may gradually come to a standstill or may even cease altogether.

The springer is generally recognized as an incipient swell, due either to pre-processing decomposition, or to subdued or retarded post-processing decomposition.

The Flipper.—The flipper differs somewhat from the springer. If the can is energetically struck against a firm object, the end bulges, resembling a swell. If the reverse end is now struck down, it will in turn bulge. Thus one end of such can appears nearly normal and the other resembles a swell. If, now the swell end is carefully pressed down, both ends are normal, or nearly so. Canners generally consider the flipper a condition resulting from the manner of capping, or due to the manner of par-boiling, or perhaps due to the quality or graining of the tin, or the nature (weight, liquidity or consistency) of the food substance, etc. Analysts are inclined to look upon the flipper as an incipient springer or swell, and this is no doubt in accordance with fact in many instances. It is certainly a fact that most, if not all, flippers show abundant micro-organisms.

The flipper condition is especially noticeable in canned corn, less commonly in canned peas, in canned condensed and in sweetened milk. For the present, all flippers should be looked upon with suspicion and food from such cans should not be eaten until it has been pronounced wholesome after being carefully analyzed and tested. It is sometimes surprising to find how small a number of yeasts, or even bacterial forms, may cause quite marked bulging of a can. *All swells, and marked springers should be rejected without further examination.*

Flat Sours.—Quite frequently cans are found with ends not bulging, nor yet somewhat concave or depressed (as they should be if properly processed), but perfectly flat. Opening such cans shows no marked gas formation and there is usually a sourish odor and taste, and other evidence of spoilage. *All flat sours should be rejected without further examination.*

Leaks.—Leaks, as a rule are not swells or flippers, as must be quite evident. Occasionally a very slight leak may seal itself and afterwards the can may become a swell or springer. Leaks may be at the seam, rim, or top. They may be due to rust pin holes. The leaks are, as a rule, quite clearly evident, from the smears of escaped liquid contents, and gummy, smeary, dirty, greasy deposits on the outside of can about the leak. *All leaks should be rejected without further examination.*

Rusted Cans.—Long stored, damp stored cans, and water and fire salvaged canned foods, may become rusty on the outside. By and by the tin will rust through in spots (pin holes), and soon thereafter the contents will begin to decompose, due to the entrance of rotting bacteria and of other micro-organisms. All more or less rusty, and water and fire damaged canned foods must be looked upon with suspicion. The contents of the cans may be good and yet on the other hand they may not be.

Definite evidence of spoilage, such as swells, springers, leaks, and cans that are decidedly rusty, cause the food analyst little trouble. There is a general popular belief among the trade that foods in cans that are intact and bright and clean externally, with no evidence of swelling or leakage, are good and wholesome. This is far from the actual facts. Most of the harm from canned foods comes from eating foods taken from cans that appear to be in excellent condition (judged from external appearances). The causes of decomposition changes in canned foods, of a subdued or retarded nature, may be briefly stated as follows:

(*a*) **Insufficient or Inadequate Processing.**—If the temperature necessary to kill all organisms (inclusive of their spores) present in food substances in the cans, is not sufficiently high (100°C. to 120°C.), or is not applied for a sufficiently long period of time (from 30 minutes to about two hours), or is not applied often enough (fractional sterilization), the food materials in the cans will gradually undergo decomposition. The character and the degree of decomposition is extremely variable, depending upon the nature of the organisms which survive the incomplete sterilization (insufficient processing), the nature of the food substance (vegetable, animal, or mixed; seasoned or not; salted or not; kippered; etc.), time of storage, and upon the temperature at which the cans were stored.

There are many practical cannery problems awaiting solution. It is only within very recent years that some of the leaders in the food canning industry have realized the great importance of applying scientific methods and some of them have in their employ highly qualified bacteriologists and micro-analysts.

(*b*) **Imperfect or Defective Sealing of Cans.**—This is certainly a fruitful source of canned food spoilage. The food may be pure and wholesome and the cannery processing may have been absolutely perfect, yet if the capping or the sealing of the containers is imperfect or defective in some way, the food will in time spoil. Corks used may be old and mold infested, tin caps used may be old and rusty, the rubber fittings may be bad. In canned (tin cans) goods the capping may be defective or the soldering may be imperfect. The soldered cans are now largely replaced by the modern sanitary can. The friction cap can has apparently proven quite unsatisfactory. Many of the subdued decomposition changes referred to occur in foods put up in friction cap cans. They should be discarded for the sanitary can. The old method of soldering on the caps leaves nothing to be desired, provided, the soldering is carefully done.

(*c*) **Pre-processing Spoilage.** Unprincipled canners have put up food which they knew to be spoilt at the time of processing. The cans, if sufficiently processed, may appear quite normal, though in most instances, even the most severe processing leaves evidence of incipient swell. The value of the organoleptic testing in such cases is considerable, though sometimes doubtful. The odor may be bad or merely slightly "off," and again it may be merely hypo- or hyper-normal, these variations depending upon the kind and the degree of decomposition, prior to processing, and the kind and the degree of decomposition subsequent to insufficient processing, and also upon the age of the canned food.

(*d*) **Post-processing Spoilage.**—This is wholly due to insufficient or inadequate processing, and to imperfect capping, soldering or sealing, and to leaks of all kinds. A leak may be defined as any condition of the can which will allow micro-organisms of any kind, to enter the can and contaminate the contents; and, may be due to imperfect sealing, puncture, opened seams, rust pin holes, or to too sudden cooling of the cans after processing.

In post-processing spoilage the microscopical picture is often markedly different from that in pre-processing spoilage. The micro-organisms (bacteria) may show active motion. The yeast cells may show distinct vacuoles and absence of cell-wall coloration (due to absorbed coloring matter), indicating that they are alive. There may be gas bubbles distributed through the food mass, there may be odors indicating the nature of the dominant infection (putrid, nauseous, bad, fruity, vinous, etc.). There may be much gas formation and again there may be no gas formation whatsoever. There may be marked decomposition, with billions of micro-organisms per cc. or per gram, and yet without distinct odor, or gas formation.

3. Frozen Foods

Food substances frozen solid and kept in such a state will not undergo microbic decomposition for long periods of time, provided that foods were good and wholesome at the time of freezing. A story has been current among naturalists, that modern Eskimo dogs have been seen feeding upon the meat of the long extinct mastodon, frozen in the polar ice. Frozen foods cached by polar explorers have kept in good condition for several years.

As long as the temperature of the frozen food is kept at 0°C. or lower, there is practically no bacterial development. It is claimed, however, that there are some bacteria which will develop very slowly at 0°C. and it is known that even prolonged exposure to −175°C. does not kill many bacteria.

4. Cold Storage Foods

The cold storage temperature is usually considerably above 0°C. and should always be below 40°C. It is, even at its best, a variable temperature, ranging between the extremes given. The cold storage does subdue and retard, and temporarily reduce, food decomposition. In the case of contaminated and partially decomposed food substances, cold storage actually reduces the number of living organisms present; soon, however, the original number is again reached, after which there is a slow but steady increase in the number of micro-organisms, which proves conclusively that cold storage does not prevent the decomposition changes. It does subdue, check and retard such changes, and modifies them qualitatively, as has already been pointed out.

It is declared that cold storage favors those molecular changes in foods, meats in particular, which make for improvement in flavor and texture. Tough meat becomes more tender, and strong flavored meats (strong natural flavors, sex flavor, fish flavor, wild game flavor, etc.) become mellowed and improved. Some consider the preference for long cold stored meats (10 to 20 weeks) as a perverted taste.

In brief, the decomposition changes in cold stored food substances, are essentially of two kinds; A modified bacterial decomposition, and the comparatively slow but nevertheless inevitable molecular and enzymatic disintegrations which come with time. Other incident changes are variable degrees of loss of moisture, loss in volume and weight, change in texture, reduction in food value and in digestibility, etc.

Of the greatest importance are the retarded, subdued and qualitatively modified, bacterial decompositions. A vast array of more or less severe intoxications have been laid to the eating of stored foods which have undergone such decomposition changes. All cold storage foods should be carefully examined before passing judgment upon them. All cold storage foods of doubtful quality should be rejected as unsuitable for human consumption.

Some of the purely gross organic and certain purely molecular changes, resulting from the combined influences of time and lowered temperature, require further careful study. For example, cold storage and frozen broken eggs, show numerous microscopic albuminous aggregates, resembling amebæ (slowly motile forms and resting forms). Remnants of molecularly disintegrated muscle fibers (ultimate elements) have been mistaken for streptococcus and streptobacillus forms. Granular cell elements, due to molecular disintegration have been mistaken for small bacillar and coccus forms. Crystals of tin salts in canned foods have been mistaken for bacilli. Clusters of fat crystals have been mistaken for mold and Leptothrix forms, a mistake which heating would have disclosed since the fat crystals melt quickly while the mold hyphæ remain unchanged.

5. Dried Foods

Since all micro-organisms require considerable moisture for their rapid growth and development, it follows that completely dried foods cannot undergo microbial decomposition, provided the foods are kept thoroughly dry at all times.

(*a*) **Completely Dried Foods.**—Ordinarily, all wholesome dried food substances (as cereals, beans, ripe peas, ripe corn, nuts of all kinds, flours, meals, etc.) will keep in a good condition for long periods of time. However, the normal atmospheric moisture to which these substances are exposed, will, in time, permit retarded microbic, and other, decompositions to take place. Such foods may thus become entirely vitiated due to molds, mites, insect larvæ, and also yeasts and bacteria. Some dry and dried food substances are more hygroscopic than others, resulting in a variation in the kind, rate and degree of decomposition. Dry vegetable foods rich in gums, mucilages and sugars are more hygroscopic than starchy foods and these latter are more hygroscopic than those which contain little or no starch. Pure cellulose may be dried to the brittleness of glass. Vegetable substances, rich in inulin, pectin, and gums, are reduced to dryness with great difficulty, and it is practically impossible to keep them in a dry brittle state under usual atmospheric conditions. They may be kept in hermetically sealed containers.

(*b*) **Partially and Incompletely Dried Foods.**—Such food substances as dried apples, dried peaches, dried pears, dried string beans, sliced dried meats, dried tomatoes, and many other dried foods, usually contain a considerable amount of moisture, and are, furthermore, so highly hygroscopic that it is quite difficult and even practically impossible to render them absolutely dry and to keep them in the absolutely dry state. Such foods must be stored in dry cool places, or preservatives must be added, in order to keep them until desired or required for consumption. Molds of various kinds, mites, bacteria, and occasionally also yeasts, are the organisms causing the decomposition changes in these foods. With reasonable care such foods may, however, be kept in good condition for considerable periods of time. They may be pressed into cakes or put up in packages, as is done with raisins, dates, figs, and many of the so-called dehydrated vegetables, as cabbage, potatoes, spinach, tomatoes, beets, and carrots.

(*c*) **Pastes and Moist Solid Foods.**—This includes pastes of all kinds (animal and vegetable), conserves, jams, jellies; fresh, cooked, smoked and pickled meats; fresh, cooked and pickled vegetables; and fleshy roots, tubers, and fruits. Unless preserved in some way, these foods, especially those of animal origin, begin to decompose at once and within a short time (several days to several weeks), most of them become unsuitable for human consumption. In some instances, nature furnishes a more or less efficient means of preservation, as the continued life of the cell plasm (after separation from the mother plant), assisted by the sphærocytes (as in green vegetables; fresh fruits of all kinds, fleshy roots, tubers and bulbs); the rind of fruits and the seed coat (testa) of seeds; the epidermal tissues generally; and the presence of such antiseptic substances as aromatic oils, and acids (malic, tartaric, citric, benzoic, etc). Ordinarily the decomposition changes in the above mentioned food substance are not considered unusual, or retarded, or subdued. As to rate and degree of decomposition, they do form the connecting link between the definitely subdued and retarded decomposition changes already mentioned (1, 2, 3 and 4) and the wholly unchecked decomposition observed in the usual liquid and semi-liquid foods, as milk, prepared dishes of all kinds, soups, and freely exposed and unpreserved liquid and semi-liquid or semi-solid foods generally.

IV. FOODS ESPECIALLY LIABLE TO BE HARMFUL OR DANGEROUS

It is well-known that some food substances spoil or decompose more readily and more quickly than others. Many food substances are or may be likely carriers of dangerous and harmful infections, without manifesting any special tendency to the usual rotting or decomposition changes.

1. Contaminated Vegetables of all Kinds

Greens, fresh fruits and vegetables generally, may contain or carry infections, such as typhoid, cholera, bacillary dysentery, amebic dysentery, very rarely also tuberculosis, diphtheria, infectious sore throat, and other pathogens and toxigens; depending upon climate, season, and other environmental conditions. Vegetables are well recognized carriers of cholera infection in cholera districts. Spinach, lettuce, cress, cabbage and other vegetables from fields or truck gardens irrigated with sewage or fertilized with human excreta, as practiced by the Chinese and also by other Oriental truck gardeners, may contain dysentery, typhoid and other infections. Canned spinach has been found on the marked heavily polluted with the *Streptococcus fecalis* and other intestinal organisms, including larvæ of intestinal parasites.

Fresh clean fruits are usually quite free from objectionable contamination, excepting such as may cling to the exterior, traceable to dirty hands and dirty boxes and baskets used in handling and shipping. Fruits, especially the banana, as possible carriers of amebic dysentery require further investigation.

A possible, though rather unlikely source of food poisoning, is the deposits from arsenical and other chemical sprays applied to fruits and vegetables as pest eradicators. Apples, pears, and other fruits occasionally show "arsenical burns."

It is a notorious fact, that dirt and filth contaminated vegetables are difficult to clean, as any housewife can testify. It will be found, for example, that lettuce or spinach, washed repeatedly (five to eight times) in liberal quantities of renewed clean water, is freed of the coarser dirt and sand particles only. Abundant micro-organisms, spores, yeasts, and mold, still remain upon the leaf (epidermis) surfaces and in the tissues. It is impractical, if not impossible, to cleanse adequately any sewage contaminated vegetable food substance, hence all foods so contaminated must be rejected as unsuitable for human consumption.

2. Frozen Foods and Cold Storage Foods

The chief reasons why frozen and cold storage foods are more or less dangerous have already been set forth. In frozen Arctic countries, the temperature may be sufficiently low or may readily be kept sufficiently low, to prevent or reduce to a minimum all food decomposition. Under the usual condition in temperate, warm and hot countries, this is difficult, if not impossible. The usual cold storage temperature does not prevent decomposition, and furthermore, the foods may have been more or less decomposed at the time of entering storage. So-called frozen foods as ice-cream, frozen eggs, frozen oysters and frozen meats, have frequently been responsible for fatal poisoning and more or less serious intoxications.

3. Sea Food

Fish of all kinds, oysters and other shellfish (as mussels, clams, and abalones), shrimps, and crustaceans generally, are quite liable to decomposition in the comparative sense. It has long been known that meat from the lower animals generally, is less resistent to decomposition, than is the meat from the higher animals. Beef keeps better and longer than does fish, under like conditions. Cod, and some other species of fish, is preserved with difficulty. Some fish (in tropical seas) are normally toxic. The roe of certain fish is said to be toxic. There is a belief current among fishermen that some kinds of fish will begin to decompose almost as soon as taken from the hook. It is a fact that much of the spoilage of canned fish is due to the failure to clean and process the fish soon enough. Fish preserved in brine, in salt, in salt and borax, or smoked, or both salted and smoked, undergoes slow decomposition and may have been more or less decomposed prior to the addition of the preservatives. Attempts have been made to transport fresh oysters and fresh fish across the American continent by express (three to four days) kept on ice. This has proved unsatisfactory, as the temperature did not prevent decomposition, and a number of cases of poisoning were traced to eating such oysters and fish. Ice packed fish and oysters should keep wholesome for several days at least, provided such foods were wholesome and free from contamination at the time of placing them on ice.

4. Sausages and Sausage Meats

The chief reason why sausages and sausage meats are especially dangerous, is that dirt and filth contaminated meat trimmings and meat scraps are frequently used, and these have usually been lying around for from one to three days before being made into sausage, during which time advanced decomposition changes have set in. Sausages, in casings, made from fresh meat, are generally wholesome, and if cooked and smoked will keep for six months and longer. The casings may be coated with bacteria on the outside, and yet the meat within may be quite free from contamination; however, if the sausages have been stored in a well ventilated, dry, cool place, the exterior of the casings should also be quite free from bacteria and mold.

The sausage meats in bulk, and large sausages, may contain the *Bacillus botulinus* in the interior of the mass, and abundant rotting bacteria upon the exterior. Artificial coloring and chemical preservatives may be added. More generally the red coloring is applied to the casings only. Recently, sausage substitutes or so-called "meatless sausages" have appeared upon the market made from "fish bellies" and fish scraps and trimmings. Horse meat and whale meat are added to sausages. Beef is usually added to pork sausage. Many sausages contain an excess of fat trimmings. Fetuses are said to be used. Among the sausage fillers most commonly employed (to increase the water content from 3 to 25 per cent.) are cereal (corn and rice) and gum tragacanth. Meat from old and even diseased animals may be used. Animals dead or dying of hog cholera have been made into sausage, or have even been dressed and sold as slaughtered pork.

All sausages and all sausage meats and minced meats should be carefully examined before accepting them as suitable for human consumption. So-called potted meats and deviled meats especially, require careful examination, as they are often made from trimmings and other meat scraps.

5. Pastes of All Kinds

Nearly all of the animal as well as vegetable pastes found upon the market are more or less decomposed by bacteria, mold, and occasionally yeasts. Meat pastes are generally made from trimmings and the process of manufacture of all pastes is usually such as to favor microbic decomposition. The bacterial count in vegetable pastes is frequently very high, exceeding 25,000,000,000 per gram.[1] It would be advisable to reject all pastes, unless some guarantee can be given that they are prepared from wholesome materials and that the process of manufacture is such as not to allow excessive decomposition to take place. Many cases of fatal poisoning have been traced to the eating of pastes, both animal and vegetable.

6. Irregularly Fermented Food Substances

Regularly fermented or ripened food substances, such as soured milks, cheeses, soja sauce, Sauerkraut, are as a rule, free from foreign objectionable contaminations and may be unhesitatingly used in the manner intended. Irregularly and incidentally or unintentionally fermented food products, such as some home made cheeses, tomato pastes, some pickled products, and some fruit products (apple butter, pie stocks), are, as a rule, more or less objectionable because of the fact that some of the organisms of decomposition which are present may be toxigenic or otherwise harmful. Many of the restaurant apple pie stocks now found upon the market are of such bad quality that the pies made therefrom are practically inedible and as a result the eating of restaurant apple pie is now greatly reduced. Very few tomato pastes or tomato sauces are suitable for human consumption, due to the excessive bacterial and mold contamination. Many of the mince pie stocks are badly contaminated by molds, spores, yeasts, and bacteria, and are furthermore usually quite short on meat. Apricot and peach pie stocks are generally of fair quality, as far as decomposition due to micro-organisms is concerned. All bulk pie stocks should be carefully examined before pronouncing them suitable for human consumption.

7. Improperly Handled and Improperly Prepared Meats

Fresh meats without preservatives of any kind, quickly undergo decomposition. Careless handling, unnecessary exposure to dust, dirt, and flies, hasten and augment the decomposition changes, The wagons and other conveyances for meat are often filthy and the meats carried in them are generally not covered at all, or the covering canvas may be filthy. The meat at the meat shops or in the public markets, is frequently not screened against flies and may be openly exposed to the dust and dirt of the streets. Meats often show the marks of dirty boots, or mud from the street, or filth from the wagon, cart, box or basket, to say nothing about the contamination from hands, tools, and work tables of retail meat handlers and merchants. The meat blocks are, as a rule, highly contaminated by bacteria.

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[1] The highest count thus far recorded was that of a marketed tomato paste showing over 32,000,000,000 bacteria per gram. Chopped meats (pork) have revealed as many as 43,000,000,000 bacteria per gram of the meat. This meat had a very putrid odor.

8. Overripe Fruits

The effects (on digestion and assimilation) due to eating overripe fruits are not clearly understood. There is a general opinion that such fruits are injurious to health and many food intoxications have been laid to them. It has been suggested that some forms of auto-intoxications arise from eating overripe fruits.

It is not always readily ascertainable as to where the purely overripening changes (molecular disintegration or decomposition) leave off and where the microbic decompositions or rotting changes begin. There can be no doubt that the ultimate changes which take place in overripe fruits prepare the way for the rotting changes due to bacteria and molds.

The most marked initial change observed in over-ripening is an increase in the sphærocytes (nucleo-sphærocytes) accompanied by an increase in various lytic activities (due to diastase, cytase, proteases, lipases), and loss in water content. The fruit becomes soft, easily crushed to a pulp, discolored, brittle, even mealy and dry. The immediate transition from overripening to rotting or decay, is marked by a regaining of moisture and gradually the erstwhile comparatively dry friable and mealy fruit becomes soft and mushy, accompanied by a change in color and in aroma. Finally, the entire fruit becomes so soft that it can no longer be handled without breaking up the tissues. Apples, peaches, pears, figs, watermelons, cantaloupes. grapes, bananas, and tomatoes are apt to show the overripe changes,

The overripening changes are merely the continuation of the ripening changes and take place after the physiological life connections between the fruit and the mother plant are practically at an end, and all of the chemical changes are essentially catabolic or destructive, with the exception of the activities of the sphærocytes which arise from the cell-plasm of the fruit cells.

9. Over-ripened and Over-aged Foods

Ripening changes in foods, as generally understood, are physical (molecular) and chemical, rather than rotting, and take place in raw, and unpreserved foods during storage. Meats in cold storage are said to ripen. Immature fruits of all kinds are set aside in dry cool places to ripen. Green bananas ripen during shipment. The over-ripening changes are in fact closely similar to the overripening changes already mentioned. The former changes take place after the death of the plant or animal, or in the plant part or animal substance after its separation from or removal from the individual whole upon which it grew. The latter changes take place in living plant parts (fruits in particular) and in animal tissues which are still organically connected with the living individual whole. An apple may become over-ripened after being detached from the tree; it will overripen on the tree. Melons may overripen on the vines; they will over-ripen in prolonged storage. Potatoes will overripen in the soil still attached to the vines; they will over-ripen in the cellar or in the earth mound. Meats may be said to over-ripen only, unless it is permissible to speak of the meats of living old animals as over-ripe.

The essential difference between over-ripe and overripe foods is that the microbic decomposition changes which will set in in the former instance are apt to be more varied, more active, and more harmful, than similar decomposition changes in the latter instance. There may be and are numerous exceptions however. For example, ripe apples will keep much better in storage than they will if left on the trees. An apple which matures or ripens on the tree is said to ripen naturally, while a green apple plucked from the tree and allowed to ripen in storage is artificially ripened. Natural ripening is, without exception, preferable. Overripening, which is a more or less natural process, is preferable, or stating it more correctly, is less injurious than over-ripening, which is artificial.

Over-ripening as well as overripening changes are the fore-runners of decay or rotting and these merge or gradate into each other in such a way as to make it practically impossible to say definitely where the one leaves off and where the other begins. Over-ripening changes are similar to those of over-storing and all over-stored foods should be looked upon with suspicion and should be carefully examined before being passed upon.

The morphological and chemical changes in canned and preserved foods due to long storage are little understood. Barring microbic decompositions, the time changes in such foods are generally believed to be harmless. However, in consideration of what has already been stated under retarded and subdued fermentations and decompositions, it is advisable to examine all long stored, and preserved and canned foods, carefully before passing upon them.

The molecular (physico-chemical) changes in stored foods require further careful study. The explanation of the true nature of such changes is to be found in the realms of physical science, rather than in microbiology or in chemical science. No doubt the physical energies (molecular or electronic) which causes the Brownian movement of minute particles suspended in liquids, also cause the molecular disintegration of organic matter, assisted and hastened by enzymatic action.

The chief danger in fermented food products, such as cheese, sour milk, Sauerkraut, pickles, etc., lies in the fact that secondary fermentative changes of an objectionable character may set in. Cheese thus vitiated may become highly toxic. Foreign organisms may render the Sauerkraut, pickles, pickled olives, etc., unsuitable for consumption.

It must also be borne in mind, that, as a rule, fermented foods are to be eaten in small quantities only, more as relishes, rather than as regular articles of diet. This applies especially to cheese; relishes so-called; pickles; olives; fermented sauces; etc. However, soured milks and Sauerkraut are very generally consumed in liberal quantities.

Pathogenic organisms do not, as a rule, thrive in fermented foods and it is rare indeed that a disease is traced to such source. The *Bacillus tuberculosis* has been found in cheese, but the transmission of tuberculosis through the eating of cheese is unlikely. On the other hand toxigenic symbionts or saprophytes do occasionally appear in fermented foods.

The objectional characters of irregularly fermented food substances have been referred to. All pastes and many of the so-called relishes and pickled compounds of animal and vegetable substances belong here. These should be carefully examined for the presence of bacteria, yeasts, spores, and mold hyphæ not concerned in the fermentation proper. Most of them are unsuitable for human consumption because of the number and variety of microorganisms present.

V. FOOD SUBSTANCES NOT LIKELY TO UNDERGO MICROBIC DECOMPOSITION

There are few organic food substances which do not sooner or later undergo microbic decomposition. There are, however, some very notable differences in the rate of such decomposition changes as has been known for many ages. The following food substances are, as a rule, fairly free from decomposition and pollution.

1. Dry Seeds and Dry Fruits

The edible quality of ripe cereals, including corn, remains unimpaired for years, if kept in a dry cool place. Wheat grains have been found with Egyptian mummies and ears of corn with Mexican mummies, in well-preserved condition. Other seeds, especially those rich in starch, with comparatively little fat and oil, will also keep for years. Seeds and fruits rich in fat and oil will sooner or later become rancid, and will, as a rule, not keep in good condition for more than a few years. Black walnuts and butternuts have been found in fairly good condition after 25 years. Peanuts, cocoa, nuts or seeds, almonds, and other comparatively dry seeds, rich in fat, will keep in good condition for a number of years, while other seeds rich in oil, such as castor beans, and croton beans, will usually become rancid within a year or two.

Starch is somewhat hygroscopic and hence all seeds and fruits rich in starch, such as cereals, beans, peas, lentils, corn, and Kaffir corn, should be kept in a dry place. If stored in a damp place, retarded bacterial decomposition will set in, also mold contamination, to say nothing of weevils and other animal parasites.

Some of the sliced, broken, and granulated, well dried starchy vegetables, as potatoes, bananas, artichokes; and also dried comparatively non-hygroscopic vegetables, as turnips, spinach, carrots and beets; will keep fairly well.

2. Flours and Meals

All of the substances mentioned in (1) may be, and are, frequently ground into meals or flours. In addition, many of the starchy roots and tubers and such starchy fruits as the banana, are made into flour, after thorough drying. Because of the increased surface exposure of the starch in the meals and flours, the necessity for keeping dry is correspondingly greater than it is for the dried seeds or fruits from which such meals and flours are made.

The *Bacillus coli* is quite common in cereals. Most cereal flours are fairly rich in bacteria and no doubt the cases of cereal poisoning (sitotoxismus) are due to the presence of toxigenic bacteria. Mold may develop in damp flour, and also mites and other organisms.

Cereals, beans, peas, lentils, etc., may be shrunken and shriveled, mold blackened, infested by larvæ, and by insects, and may contain an excess of dirt and sand.

3. Canned Goods

The question is often asked: How long will canned foods remain edible or wholesome? Foods that were fresh, pure, and wholesome at the time of canning and which are adequately and properly processed in well-sealed modern sanitary cans, will keep in good condition for five years and longer, provided the cans are stored in a dry cool place and do not rust. This implies the use of modern sanitary or practically ideal cannery methods. However, as already stated, the use of wholly practically applicable sanitary cannery methods do not prevail as yet. It is for this very reason that *all* canned foods, no matter by what firm they are put up, must be very carefully examined, before being passed upon.

4. Smoked Meats

Meats may be smoked fresh, but more generally they are first salted or placed in brine and then smoked. Kippered fish (salmon sturgeon, herring, etc.) is usually halved, salted and smoked. Pork (shoulder, hams, bacon) is generally salted for a time and then smoked, and such meat, if it was good and wholesome at the time of salting and smoking, will keep for some time, if enclosed in a protective covering and kept in a dry cool place. Mold (*Penicillium glaucum*) will soon develop upon the exterior if the meat is kept in a damp place. Maggots may also appear in the loose connective tissues and about the exposed bones. Poisoning has been traced to the eating of old and stale smoked meat.

Salted and smoked meats of all kinds will stand rough usage and may be transported in bulk without difficulty. Thinly sliced smoked meats will undergo microbic and mold decomposition fairly readily and hence smoked meats should not be thus prepared unless intended for almost immediate consumption. The sliced smoked meats found upon the market, usually put up in small glass containers, are, as a rule, more or less spoilt by molds and bacteria and should not be eaten.

Dried meats (jerked beef, biltong, pemmican), especially if also salted and smoked, will keep for long periods of time, of course, provided they are kept in a dry cool place.

5. Fresh Fruits

Fresh, wholesome fruits of all kinds, free from rotting and other objectionable contaminations, will, if properly stored, keep in good condition for periods of time represented by the natural and artificial ripening changes, up to the overipening and over-ripening changes, already referred to.

Whole, intact, fresh ripe fruits, as a rule, require no special examination, beyond careful organoleptic testing. The skin or peel is nature's protection against infections and contaminations of all kinds, as well as against rapid loss of moisture and atmospheric oxidation changes. For reasons which are self-evident, the skin, rind, or peel, should be removed before eating, taking with it the infections which may be clinging to it.

Fresh vegetables, as lettuce, spinach, cabbage, celery, including fleshy roots and tubers, and bulbs, require careful looking after as they may be dangerously polluted, and furthermore, they decompose readily, hence must be cooked and otherwise prepared, and consumed promptly. The changes induced by the usual rotting bacteria are readily discernible, but the sewage and other harmful pollutions call for careful microscopical examination and special bacteriological and biological tests.

6. Dry Extracts

There are only a few extracts which require mention. So-called solid meat extract (as a paste, bouillon cubes, etc.) is a most valuable article. Hot beef extract has remarkable warming and stimulating properties. Its food value is, however, practically *nil*. Coffee extract is used in place of the bean and is most desirable for purposes of the quick preparation of the drink coffee.

The odor of beef extract is frequently very bad, due to bacteria which are usually present in large numbers. Extracts having a very bad odor should be rejected without further examination. However, carefully prepared meat extracts will keep for periods of six months and longer. Other animal extracts such as bile or ox-gall, pepsin, pancreatin, ingluvin, and the recent ductless and other glandular extracts; inclusive of certain vegetable extracts, as papain, decompose quite readily, unless very carefully prepared and all such products should be carefully examined microscopically and bacteriologically.

The bouillon cubes (wrapped in tin foil) contain from 50 to 70 per cent. salt, 8 to 30 per cent. meat extract, and from 3 to 25 per cent. vegetable extract. In the inferior grades of bouillon cubes, the percentage of salt is usually very high, in spite of which they often run very high in bacteria.

VI. FOOD ANALYSIS IN THE FIELD

1. The Food Microanalyst

The army food microanalyst should be attached to the Quartermaster's Department, in times of peace as well as in times of war. He should be required to visit all places where foods are kept or stored in quantities and where foods are prepared and served to the men, as in camps, army division headquarters, the mess unit, etc., inspecting the foods and making the required microscopical examination and other tests, on the spot, including the filing of the reports of findings, with recommendations.

The microscopical as well as macroscopical (organoleptic) examination should be made in daylight, in so far as possible. Artificial light (candle, oil lamp, acetylene light, electric light) may be used when sunlight is not available.

(*a*) **Qualifications.**—The microanalyst must have had at least a university training, or its educational equivalent, as a preparatory requirement. In addition he must have made careful microscopical examinations of all substances which may be so examined and that includes practically everything of a material nature. Skilled microanalysts are rare. There are indeed many students who have been taught certain things about the microscope and who have examined and reported upon certain microscopic objects and there are many bacteriologists, biologists, chemists, and other investigators, who make occasional use of the compound microscope, but these are not microanalysts in the true sense of the term. The army microanalyst must be able to recognize at a single glance all of the objects which may appear within any field of view of the compound microscope and he must be able to interpret all findings with reasonable correctness and without hesitation or delay. It therefore follows, that in addition to his extended technical training he must have had a very wide range of experience and must be endowed with keen perception and good judgment. Novices in this line of work would prove useless in the field, as well as in the laboratory, and would only cause confusion and bring discredit upon the work.

The microanalyst must be endowed with good special sense development. His sense of sight, smell, and taste must be well developed and normal. In order that the judgment of taste and odor sensations may be normal, he must be a total abstainer from tobacco, from alcoholic drinks as well as from other habit forming poisons. The moderate use of coffee and of other true cerebro-spinal stimulants may on occasion prove useful and desirable.

The army field microanalyst must be able to do without most of the reagents and the accessory apparatus usually found in food laboratories. There will be little time or opportunity for the use of stains, special micro-chemical reagents or of special apparatus. Yet, his work must be reliable to the highest degree. He must be endowed with ingenuity and mechanical skill in order that he may meet all arising exigencies. He should not be a mere machine, contented with doing certain assigned work. He should possess initiative, more especially in the development of his usefulness in the broader sense. His main work is indeed the safe guarding of the men against bad foods of all kinds, but he should ever be on the alert for opportunities to assist the sanitarians, the surgeons and in certain phases of the secret service. He must ever have his working equipment with him and he should be in position to begin work anywhere, at once, whether in field, in camp, in kitchen, or in the hospital. Each analyst must be an independent working unit and must rely upon his own ability.

(*b*) **The Field Equipment.**—The field equipment of the microanalyst must be the best obtainable and must be simple and practical. The entire field outfit must be carried by the analyst, with the exception of such improvisations as may be made on the spot. In other words, the entire equipment must be portable and capable of being set up and used anywhere. The following are the essentials of the equipment.

The Compound Microscope.—This constitutes the basic part of the equipment. The analysts qualified to use this apparatus are familiar with its construction and use. A few suggestions only are submitted. Two duplicate oculars should be on hand, and there should be a triple nosepiece carrying three objectives, one giving a magnification of 85 to 90 diameters and one giving a magnification of about 450 to 500 diameters, combined with No. 10 ocular, and a good oil immersion objective. The stage should be fixed and a mechanical stage is not required, though it may be useful.

The hand case for the compound microscope and the accessories, should be in two equal parts, made of aluminum, the two parts well hinged, close fitting, strong, with strong firmly attached handles and provided with lock and key. When closed, with its contents in place, the case should not allow more than a trace of water to enter when completely immersed for from five to thirty minutes. The compartments and holders in the case should be sufficiently firm and durable to withstand reasonably rough usage.

The following are the more important accessories.

The Micrometer Scale.—For making desirable measurements a micrometer scale is required. This should be the usual ruled disc which fits into the ocular, resting upon the properly adjusted diaphragm. The eye-piece micrometer is indeed more convenient to use, but it means carrying an extra piece. The measuring values in microns of the micrometer scale should be determined in advance and marked (stamped or engraved) on the microscope itself; thus, l.p. = 16 microns; m.p. = 3.4 microns; oil im. = 1.8 microns. In like manner determine the areas (in sq. mm.) of the fields of view for the three objectives (combined with the ocular) and also record these values on the microscope. The stage micrometer scale will then be no longer required and may be omitted from the field equipment. The areas of the fields of view may also be roughly determined by means of a millimeter rule extended across the field of view on a

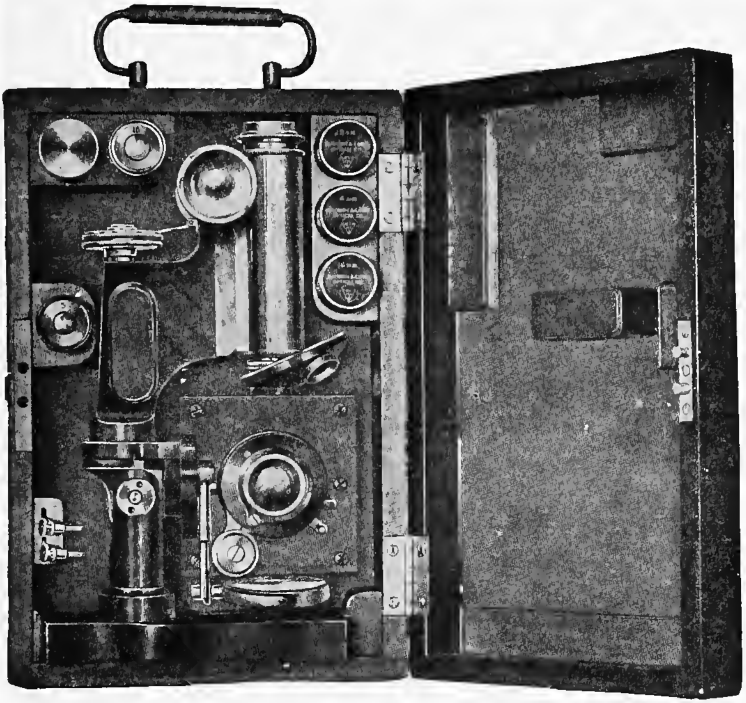

FIG. 13.—Portable microscope. This type is in a wooden case. The aluminum metal case is to be preferred, as stated in the text.

level with the stage (by the double vision method), provided the magnification is known. Conversely, the magnification of the microscope may be determined, in similar manner, provided the actual diameter of the field is first determined by means of the stage micrometer scale.

FIG. 14.—The field microanalyst at work. Examining a water supply.—(*Whipple*)

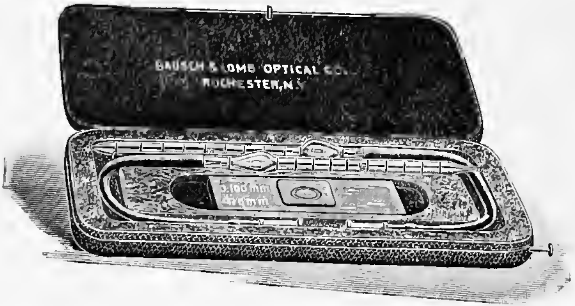

FIG. 15.—Thoma-Zeiss hemacytometer. Complete equipment for blood counting. This is very convenient for making bacterial counts in catsups, jams, jellies and other vegetable foods and also in animal food substances.

Counting Chambers.—For blood work, making bacterial counts, spore counts, yeast counts, starch counts and also other quantitative as well as qualitative micro-analyses, the Levy or Thoma-Zeiss hemacytometer (cell, counting chamber), with Turck ruling, is recommended. Of these two, the Levy cell is preferred because it is much easier to clean, and it further-

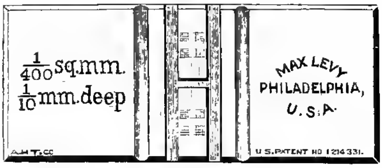

FIG. 15*a*. —Levy Counting' Chamber.

more has two counting areas, which is frequently of great advantage. For most of the rapid field work, the Schneider counting chamber is to be used. This is a plain slide with two glass strips 0.1 mm. thick, upon which the cover glass rests. This, with the known area of the field of view, will enable the analyst to make any desirable counts. The Howard counting chamber serves the same purpose, but is more expensive, besides being more difficult to clean.

Polarizer.—This is an accessory which will be found useful occasionally, more especially in the identification of starches, also for the purpose of differentiating between small crystals and bacteria. The polarizer attachment as recommended by Winton and as employed by the Bureau of Chemistry, should be used. In this the polarizer fits into the sub-stage ring and the analyzer takes the place of the ocular.

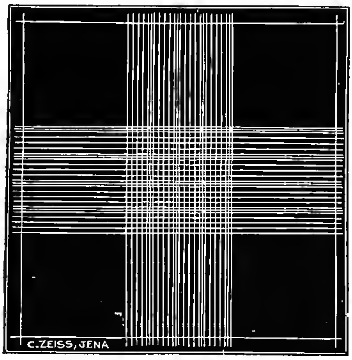

FIG. 16.

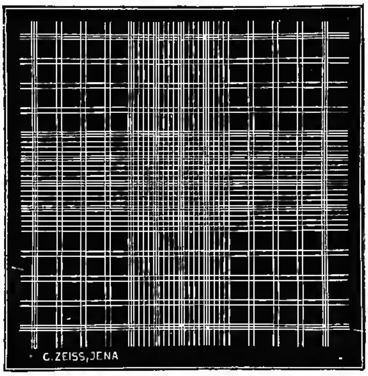

FIG. 17.

FIG. 16.—Zappert ruling of the Thoma-Zeiss hemacytometer. This form of ruling is especially convenient for making bacterial counts and counts of fat globules in milk.—(*Carl Zeiss.*)

FIG. 17.—Turck ruling of the Thoma-Zeiss hemacytometer. This is especially useful if it is desired to combine the bacterial count with the spore and yeast count. The smaller areas (1–400 sq. mm.) may be used for making the bacterial counts, while the larger areas (1–25 sq. mm.) may be used for making the spore and yeast counts.—(*Carl Zeiss.*)

The Vital Incubator.—This was described under *Bacillus coli* test, and is to be used only when a laboratory incubator is not available.

Any of the smaller hip pocket size tin smoking tobacco containers (Prince Albert or other tobacco brands) may be used as holders for the tube cultures. The tin with its contents can be placed in one of the many cloth tobacco pouches and securely tied, and the cord or bandage fasteners for waist and shoulder can be sewed to the cloth holder. The body fasteners may be omitted and the bag fastened to the undershirt by means of two safety pins.

The familiar toy rubber balloons (of assorted forms and sizes) may be used as containers for the bacterial cultures, after deflating, thorough washing and disinfecting and rinsing in alcohol and in boiled water. The larger rubber containers may be cut (transversely) into several pieces, and the ends securely tied, after filling and inoculating.

The Centrifuge.—For field purposes, the Wetherill torfuge, may be used. Better results will be attained by means of a two speed hand centrifuge. This centrifuge gives a speed ranging from 1,200 to 4,000 revolutions per minute, and will meet all practical requirements.

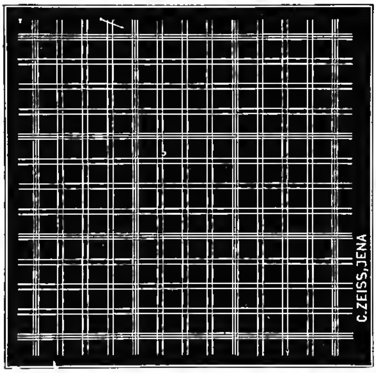

FIG. 18.—Bürker ruling, useful in making counts of milk fat globules, spores, and yeast cells. The average of many counts is taken.—(*Carl Zeiss.*)

Sedimenter.—The Wizard sedimenter, used largely for the purpose of demonstrating the amount of sediment in milk, will prove useful. This is not an essential apparatus and substitutes may be readily improvised on the spot, as a pledget of cotton or cheese cloth, or filter paper, in a funnel, to catch the coarser sediments in milk, in water, in sewage, in liquids generally. A funnel sand filter may be improvised. Place a pledget of cotton in the tube of the funnel (cheese cloth is better if funnel outlet is large), on this place fine sand, followed by another pledget of cotton or cheese cloth. Run through the desired amount of the liquid to be examined (water, milk, etc.), as 1 pint, 1 quart, 1 gallon, or more, and then mix the filtering material (cotton and sand) in a minimum amount of pure water, and examine the sediment. Rough quantitative estimates may be made by means of the counting devices

The Sling Filter.—The field analyst will find the Sedgwick-Rafter sling filter useful for gathering as well as for concentrating water plankton. It is made of metal and filtering (through a sand plug) can be hastened by swinging the funnel on an axis, thus converting it into a centrifuge. The cap at the lower end holding the sand with the sediment is attached to the funnel by means of a bayonet clutch. It will prove of great value in gathering, examining and estimating the plankton in larger bodies of water and in streams.

The Plankton Net.—The Hensen plankton net will be found very useful in examining larger bodies of water. By means of this net it is possible to concentrate organisms from large volumes of water. It is made of fine mesh silk through which the water passes while the organisms are carried down on the inside to the receiving cup at the lower end.

Other Accessories.—Slides and cover glasses (No. 2), a section knife (razor, or safety razor blades will answer), pocket magnifier (the ocular of the microscope, reversed will answer), two 10 cc. graduated cylinder; one 100 cc. graduated cylinder; 1 cc. graduated pipettes, test tubes, fermentation tubes, Petri dishes, etc., will be required. Also pencils, fountain pen, pocket note books, and field report or record book.

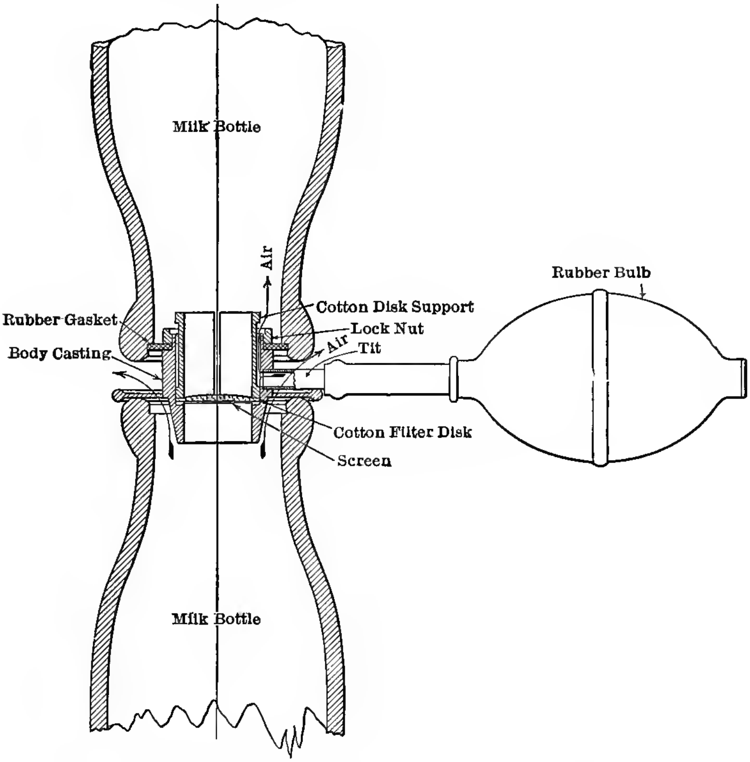

FIG. 19.—Diagrammatic representation of the Wizard sediment tester.—(*Whipple.*)

Glass tubes of various diameters, test tubes (large and small), and other glassware may be desirable for special tests.

The Micro-reagents.—These are few and the solutions are to be prepared as required. A few stains in granular or powder form (fuchsin, methylene blue), chloral hydrate, phloroglucin, alcohol, glycerine, potassium iodid, iodine, sodic hydrate and a few others, are all that will be required. Some of those named, and others which may prove useful or desirable, can no doubt be obtained

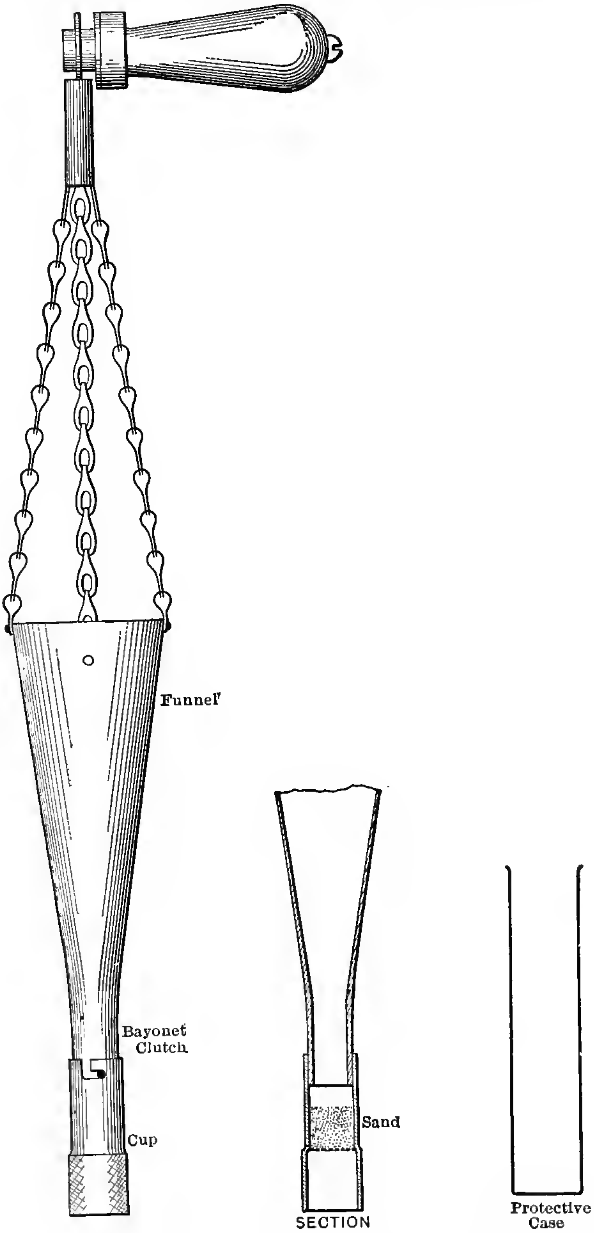

Fig. 20.—The Sedgwick-Rafter sling filter used in water analysis.—(*Whipple.*)

from the hospital supply base. Some indicators, as litmus, litmus paper, litmus pencils, turmeric, phenolphthalein, and cochineal, may be desirable.

(*c*) **Records and Reports.**—Records and reports of the microanalytical findings should be made on the spot, in a convenient pocket note book, using either fountain pen or indelible pencil. In some instances it may be desirable to make one or two copies; hence sheets of carbon paper of suitable size and form should be at hand. The rough field notes should be rewritten or transcribed, when opportunity offers, and all records should be transferred to the field report book, which should be deposited in a place of safety for future reference.

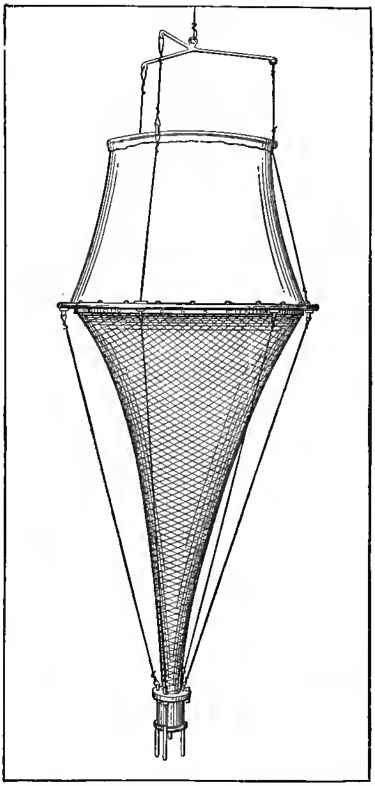

FIG. 21.—Plankton net according to Whipple. A ready made plankton net can be constructed from stiff wire, bolting cloth, and a discharged small arm shell of which the flange is slightly spread so that it can be tied to the bolting cloth.

2. The Food Bacteriologist

All necessary bacteriological examinations and tests of foods are to be made by the microanalyst. In fact most of the work done by the microanalyst is of a bacteriological nature. In fairly permanent encampments, it will be feasible and desirable to establish a properly equipped stationary bacteriological laboratory; but in active field work much of the special apparatus may not be available or may not be usable, and improvisations must be made on the spot.

The motor laboratory is a very important factor in field food and sanitation work, especially at long extended battle fronts and also along the lines of march of army divisions, as well as in temporary encampments.

3. The Food Chemist

A chemical laboratory, no matter how desirable and important it might be, is not practicable in the field. The chemical findings would, as a rule, add little of value, to the findings of the microanalyst. The army field and army camp is not the place for special chemical investigations. Such work must be done at permanently established fully equipped laboratories, working in cooperation with the Commissary Department, and under the direction of the Surgeon General.

Simple chemical and mechanical quality and purity tests of foods, are to be made by the microanalyst. Various chemicals, glassware and other apparatus which may be desirable or necessary for such tests must be secured from the hospital supply.

VII. FOOD ADULTERATIONS

This is a subject of great importance and concerning which every microanalyst should have full knowledge. Food adulteration has been practiced ever since there have been dealers in food supplies. It is, in fact, the chief work of the microanalyst to detect such adulterations, especially those which might prove inimical to the health and well-being of the men.

1. Kinds of Food Adulterations

The kinds of food adulteration are legion. From the time of the enforcement of the Federal Pure Food and Drugs Act (June 30, 1906) up to the beginning of the recent war (1914) there had been observed a gradual lessening of food adulterations, the percentage, in certain geographical areas of the United States falling from over 50 to less than 10. Since the opening of the war adulterations have again increased until at the present writing (1918) the food conditions have returned to the status which prevailed in 1906. The grossest forms of adulterations are again coming to light, and attempts are made to market highly decomposed imported canned foods. Under the camouflage of conservation, unprincipled canners are putting up filthy and badly decomposed fruits, tomatoes in particular, and also bad meats, fish, oysters, etc. These conditions call for the best efforts of the microanalysts in the camp as well as in the field.

Much of the recent canneries output (1915–1917) in the United States was reserved for the army and also for transportation to European allies. The microscopical examination of such products has disclosed the fact that while some lots of the same kind of food and put up by one and the same canner, were fair, others were wholly unfit for consumption. This indicates the importance of the careful examination of all canned food supplies intended for the army.

Many of the forms and kinds of food adulteration which are considered important under the federal as well as state administration of the pure food and drugs acts, are of little or no concern to the army analyst. Many of the food substances analyzed in civilian laboratories do not regularly appear in the army supplies. To the army it is quite immaterial whether flavoring extracts are genuine or imitation, provided they are harmless. Artificial coloring has no place in the army food supply, as it adds nothing to the value of foods, and if added for the purpose of hiding or disguising inferiority, it will be a failure, because the inferiority will nevertheless be detected.

The chief effort of the food microanalyst is directed toward the detection of harmful and objectionable food adulterations, that is, adulterations which may or might prove detrimental to the health and well-being of the men. The action taken by the military authorities in regard to foods found to be adulterated is in many essentials different from the action which is usually taken by civil authorities. All adulterated foods which are known to be entirely harmless and readily usable, will be used. For example, capsicum with 50 parts wheat flour, or corn meal, is quite satisfactory as a spice. Black pepper with cereal is usable. Mustard with turmeric coloring is not to be destroyed or returned because of the undeclared added coloring. Wheat flour found to contain lentil flour is not to be condemned for that reason. A mixture of lard and suet is readily usable. Oleomargarine, labeled butter, is nevertheless usable for purposes to which such substance is suited, namely as a butter substitute. Even a renovated butter loaded with milk or water, if freshly prepared, may be used. Watered milk can be used. Coffee with chicory and fruits, need not be destroyed.

It is of course not intended to imply that these physiologically harmless adulterations are to be condoned or overlooked. Those responsible for the adulterations should be punished according to law, and since the adulteration was primarily done for reasons of financial gain, a proper reduction in price must be made, provided it is decided to retain and use the article in question.

2. Detection of Adulterations

This rests wholly with the microanalyst and is dependent upon his special training, skill and experience. In some cases a mere optical inspection, without the microscope, will suffice, as in ground coffee mixed with figs and chicory, or weevely beans, or moldy jams and jellies, swelled cans, stringy milk, etc. Again the sense of smell will suffice, as in tainted meats and rancid butter. In other cases the mere sense of touch, or of taste, is sufficient to prove or disprove adulteration.

The general routine for the detection of food adulterations includes:

1. The application of the organoleptic tests. Feel or touch, sight, smell, and taste, rarely also the auditory sense.
2. The microscopical examination.
3. The use of simple mechanical, chemical, and physical tests.

VIII. GENERAL AND SPECIAL MICROANALYTICAL METHODS

No attempts will be made to give full details. The following statements are to be considered as mere suggestions which may prove useful in practice.

1. The Organoleptic Tests

The organoleptic tests are of the greatest importance in field work. The tests consist in the application and use of the unaided senses, namely touch or feel, sight, smell, taste, and rarely also hearing, naming them in the order of use and of importance in testing foods. It is evident that the value of the organoleptic testing depends upon the condition of the sense organs. If the special senses are blunted, diseased, abnormal or sub-normal, they are of little value in determining the condition or quality of foods. Those afflicted with nasal catarrh, for example, cannot detect even pronouncedly bad odors and the sensations induced by marked aromas or flavors (combinations of taste and odor) are disturbed, perverted or lessened. Cold benumbs the tactile sense. Very hot and very cold substances are practically tasteless. Most users of alcohol and of tobacco in excessive amounts, have a perverted and subnormal sense of smell, as well as of taste, and their judgment regarding these special senses is practically valueless.

There is considerable difference of opinion as to the valuation to be placed upon the organoleptic testing of foods, spices and drugs, especially in regard to the finer and more delicate distinctions and differentiations. Our color terminology is in great confusion and there are only a comparatively small number of odor and taste sensations which are distinctive and which admit of ready comparison. The following suggestions should be heeded.

1. Bad odors in foods of all kinds, other than the odors observed in normal fermentative changes (as cheese), indicate that the food substance is unsuitable for human consumption. Among such odors may be mentioned the odor of tainted meat, of putrefying carcasses, of meat scrapple, and of decaying animal substances generally (in meat testing); the glue odor (in gelatines); the rancid odor (in bad butter and cream); cow dung and silage odor (in some tomato pastes); hydrogen sulphide odor (in bad beans and peas); mucous

or soiled handkerchief, or dirty wash rag odor (in a variety of more or less spoiled food substances, especially noticeable in frozen eggs, gelatine, and in many canned foods); etc. The novice is apt to construe the odor of garlic as a decomposition odor. Great caution must be observed in the interpretation of the mucus odor. Such odor clings to glass-ware and other laboratory utensils and to tumblers and dishes, wiped with towels that are no longer clean, or that were washed in an unsanitary laundry, and the odor is often very strong and almost unbearable in towels, sheets, clothing, from unsanitary laundries, cleaning establishments, etc. The analyst must make sure that such odor arises from the food article itself and is not due to the use of dirty towels, or to the use of inadequately cleaned and improperly wiped glassware. The mucus odor usually arises from subdued decomposition changes in canned milks, gelatines (sheet or granulated), some canned fruits and vegetables, and soups and soup stocks.

A fruity odor in substances that do not normally have such odor (canned tomato products, tomato pastes, canned corn) or which have an increased or modified fruit flavor, is as a rule due to the presence of yeasts. The moldy or musty odor invariably indicates mold decomposition.

The so-called fishy odor of sea foods and the clinging fish flavor of such foods, also noticeable in animals that feed upon aquatic life (wild ducks and geese), is familiar to all. It should be borne in mind that when such foods begin to undergo microbic decomposition, the fishy odor and flavor is often quite appreciably increased for a time. Later the continued decomposition changes cause a lessening and almost complete inhibition of the fishy odor, after which the rotting odor begins to be noticeable. The so-called disagreeably sour odor (other than that of vinegar) is conclusive evidence of microbic decomposition. It must constantly be kept in mind that added spices may mask the odors due to decomposition, and all heavily spiced food substances should be suspicioned. Too frequently, heavy spicing is deliberately resorted to for the purpose of masking the otherwise distinct evidence of decomposition.

Some bad odors are not clearly describable or nameable and are simply designated as bad, vile, nauseous, disagreeable, or whatever designation may seem applicable. All odors not distinctly nauseating or very bad, but which are nevertheless repellant to the olfactory organs, belong to this group, and all foods giving off such odors will in all probability be found to be in an advanced stage of decomposition. The analyst must also keep in mind that the heating, boiling and processing (canned foods of all kinds), may drive off all bad odors due to decay. Very frequently canned fish appears on the market which has but little odor of any kind, or perhaps a somewhat peculiar, faintly coffee ground odor. Such fish will, as a rule, show more or less marked evidences of pre-processing decomposition, associated with careless or inadequate gutting and cleaning.

2. Taste or gustatory tests are of lesser value than odor tests. The food substances in the so-called "flat sours" (canned foods) usually have a disagreeable acidulous taste. Salt is sometimes added to tomatoes for the purpose of freshening the taste of overripe fruits. Heavy spicing is detected by the taste and occasionally by the odor. An insipid flat taste may indicate slight decomposition. Heavy salting of meats may be done to disguise incipient rotting changes. The tastes referable to food decomposition are usually associated with the more or less disagreeable odors, and are simply designated a unpleasant or disagreeable. Mold usually gives rise to acidulous and bitter tastes, as a rule leaving a bad after taste.

The so-called metallic taste generally referred to canned foods and said to be due to tin salts, is somewhat in dispute. It is not always caused by tin salts. It is often detected in smoked and kippered fish, and occasionally in other foods that have not been in contact with tin. It is said to be due to ionizing effects.

3. The sense of sight is of the greatest importance and its value in food investigation is in direct ratio to experience. To enter into a discussion of the use and application of this special sense in determining the quality of foods would be out of place in a work of the present scope.

4. The sense of touch or of feel is occasionally of great value. Meat may be firm, soft, spongy, friable, smeary, slimy, crepitant, etc., to the touch. The sense of touch will make it possible to differentiate between wheat flour and rye flour, between flour and starch, between powdered casein and powdered milk, etc. Certain powdered substances have a crackling crisp feel, as starches, casein and dextrin, while others feel smooth, as cereal flours.

5. Since foods are noiseless as a rule, the sense of hearing is of little value in food investigation. However this sense, in combination with sight, or both sight and touch, is occasionally made use of. Thus, the crispness of starch is ascertained by touch and hearing; the spluttering of hot butter by sight and hearing, the cover glass sand test by feel and hearing combined with certain sympathetic reflex sensations.

Should there be any doubt whatsoever as to the evidence of the organoleptic tests, the microscope, and other aids to the sense organs must be employed.

2. The Direct Microscopical Examination

Examinations of food substances as to quality or as to evidence of decomposition by bacteria, yeasts and molds, may be made directly or indirectly. That is, a minute bit of the food substance may be placed on a slide or counting chamber and the quantitative or qualitative determination made directly under the suitable power of the compound microscope; or definite quantities of the food substance may be placed in or upon special culture media in order to ascertain the specific biological characteristics of the contaminating organisms. In field work the direct microscopical examination is all important. There are, however, occasions when plate cultures, fermentation tube tests and even animal tests, must be made in order to ascertain toxicity or other harmful properties of foods. The essentials of the direct examination of food substances may be stated as follows:

(*a*) **The Preliminary Examination.**—After the organoleptic testing of the food is completed, one or more ordinary slide mounts are examined in order to ascertain whether or not there is microbic or other biologic contamination, or other harmful condition, or possible adulteration, or perhaps evidence of inferiority or of misrepresentation. If the findings of a careful microscopical examination reveals nothing of an objectionable nature, and the organoleptic tests have proven satisfactory, no further examination is required and the food is passed as suitable for the purpose for which it was intended.

If the organoleptic tests indicate objectionable conditions and the slide mounts show excessive contaminating organisms, either living or dead, then the food substance is to be condemned without further examination.

There are many operations, tests, etc., of a preliminary nature which the analyst may carry out, and which will suggest themselves as occasion arises. Thus, washings may be made of vegetables, which are then examined for evidence of excessive dirt, sand, sewage, bacteria, mold, etc. Flours, meals and powdered spices are examined for weevils, insect larvæ, mites, etc. Dried fruits are examined for plant lice, mites, dirt, mold, etc.

The skilled and experienced microanalyst, can generally estimate to a fair degree of accuracy the number of bacteria, spores, yeasts, and mold hyphæ present, from the preliminary microscopical examination, without the use of the counting chambers, and in actual field practice the counting chamber is used occasionally only.

(*b*) **Making Dilutions.**—For the purpose of making counts of the bacteria or of other organisms which may be present in solid, semsolid, and liquid food substances, it is necessary to add definite quantities of the food substance to some diluent, as water. Convenient quantities to be used are 1 or 5 grams of solids and pastes, adequately comminuted by means of a small mortar and pestle; and 1: 5 or 10 cc. quantities of liquid and semi-liquid food substances. The most suitable dilutions are 1:5, 1:10, and rarely 1:100, mixing well by violent shaking, in a 25 cc. or 100 cc. graduated cylinder. Place a droplet of the well mixed substance in the cell of the counting chamber, cover with ordinary cover glass and make the counts in the usual manner. Take the average of not less than ten counts. If time will permit, and for the sake of greater academic accuracy, the average of 50 counts, from two mounts, should be taken.

If bacteria and other organisms are so abundant as to require a dilution of 1 : 100, in order that an accurate count may be made, the food article in question is certainly badly decomposed and must not be used for human consumption. In practice, therefore, the only dilutions which need be employed, are 1 : 5 and 1 : 10, and even these dilutions are employed in exceptional instances only. It will be good practice for the analyst to occasionally verify his conclusions based upon the preliminary examination (*a*), by using the counting chamber.

(*c*) **Making the Counts.**—The skilled micro-analyst requires no instructions or directions as to how to make the counts. The number of organisms present will determine whether or not the food substance is to be rejected. The unit food quantities for the counts are the gram (Gm.) and the cubic centimeter (cc.). A gram of canned meat or fish may show 3,000,000,000 bacteria; or, 1 cc. of tomato catsup may show 350,000,000 bacteria, 15,000, 000 spores and 500,000 hyphal fragments; and both articles would be pronounced unfit for human consumption.

For making accurate counts of bacteria (including bacilli, cocci, diplococci, diplobacilli, streptobacilli and streptococci), of spores and of yeasts, the Levy or Thoma Zeiss hemacytometer is to be used. If these counting chambers are not available, the Schneider counting slide or the Howard counting chamber, combined with the area of the fields of view, will be entirely satisfactory, as has already been suggested. Mold counting is to be done by means of the Schneider counter. All food substances showing mold in 25 per cent., or more, of the fields of view, with either low or high power, should be pronounced unsuitable for human consumption.

There are many factors which the microanalyst must bear in mind in making the microscopical examinations. Sand and dirt may be excessive; there may be foreign tissues of various kinds present; larvæ of intestinal parasites may be present; soil nematodes, plant lice remnants, fly remnants, insect excreta, etc., may be present. All of these findings must be kept in mind in passing judgment upon the quality of the food under examination.

Making exact bacterial counts is not essential, *provided*, it is otherwise ascertained for a certainty that the meat (or other food substance) is either *suitable* or *unsuitable* for human consumption. Let us suppose that a number of slide smears taken from the surface of meat show abundant bacteria, roughly estimated at over 2,000,000,000 per gram of the meat. Such meat is certainly not fit for human consumption, and it would be quite immaterial if the careful grinding of selected samples of the meat, and making careful mounts and a careful count, should prove the actual number of bacteria to be 6,560,000,000 per gram. It is only in cases of doubt that more exact counts are required.

(*d*) **Staining Methods.**—Occasionally it may be desirable to resort to staining in order to determine whether or not certain particles are bacteria. Particles likely to be mistaken for bacteria by the novice, are, granular coagulated proteins, ultimate elements of muscle fibers, crystalline particles, clay particles, chalk particles, talcum particles and cholesterin globules. Coccus forms, agglutinated bacilli and cocci, and the Gærtner and *B. coli* groups of bacilli, are often confused with some of the particles above mentioned. Bacteria (rod forms as well as coccus forms) stain somewhat differently from any of the organic particles mentioned, while the inorganic particles (as crystals of various kinds) remain unstained.

While it is, as a general thing, quite immaterial whether the bacteria present in foods are dead or alive, it is occasionally desirable to differentiate between dead and living micro-organisms. Motility is of course *prima facie* evidence of life in bacteria, but not all living bacteria are endowed with motion. Various methods have been proposed for determining quantitatively the presence of living bacteria, other than by the plating methods. The tellurium tetrachloride method proposed by King and Davis was intended to measure the number of living bacteria in a liquid (broth and other liquid culture media) by the amount of dark precipitate formed. Broca devised a differential stain (10 cc. carbol-fuchsin to which is added 80 cc. Loeffler's methylene blue) for living and dead bacteria. With this stain, dead bacteria are colored red while the living bacteria take on a blue coloration. This stain also differentiates between bacterial and non-bacterial particles, and may prove of value in differentiating between meats from different species of animals.

Dead yeast cells usually occur singly or in groups of not more than two as a rule, the vacuoles are wanting and the cell walls are usually more or less colored through the taking up of coloring matter from the substance in which they occur. In case of doubt, the addition of a weak solution of almost any dye will stain the walls of the dead cells whereas the living cells remain uncolored. Bacteria behave in a similar manner. Some time is required (two to fifteen minutes, depending upon the concentration or amount of the stain used) to bring out the staining contrasts. The observations must be made at once, because in time the stain will kill some or all of the living cells and gradually stain them also. It is easy to distinguish between dead and living yeasts and molds in catsups, jams, jellies and similar vegetable substances containing more or less coloring matter, as the cell walls of the dead structures appear much more distinct by virtue of having taken up some of the coloring which is present. No definite strength solution of stain is recommended, as no two workers proceed exactly alike. In a general way from 1 cc. to 5 cc. of a saturated solution (alcoholic) of the stain added to 200 cc. of distilled water, with one cc. alcohol, will give good results for a worker who devotes from three to fifeteen minutes to the microscopical examination of the mount. A more rapid worker would prefer to use a stronger solution, say 1 to 5 parts of the stock stain to 60 and even 50 cc. of distilled water, and a small amount of alcohol. Enough of the stain is mixed with the material on the slide to give it a distinct tinge and no more. Those interested in special differential staining of the various organisms which may appear in foods, in sputum, in feces, in vomit material, etc., etc., should employ the various stains usually recommended for vital staining.

For some time microanalysts have made use of standard solutions of certain stains in the study of moist (hydrated) organic substances in slide mounts. A droplet of the stain is applied near the edge of the cover glass and allowed to be drawn under by capillary action. The cell walls or other tissue elements with which the stain comes in contact soon become more or less deeply colored. Better results are obtained by mixing the stain directly with the material to be examined, before mounting. Certain substances, not of cellular nature, also present special reactions with the stains used and the staining reactions are modified by various processes, as heating, additions of chemicals, preservatives, sugar, etc., etc. Thus raw milk and heated milk react quite differently with methylene blue, making it possible through the use of this stain to determine whether or not milk has been boiled or pasteurized.

Heating the material to which the stain has been added will hasten and accentuate the contrast staining. For example, to a droplet of tomato product on a slide, add a droplet of ten per cent. methylene violet solution. Mix very thoroughly by means of a thin glass rod or dissecting needle, cover with cover glass and hold over the flame of a Bunsen burner until the material on the slide comes to a momentary brisk boil (as for driving air out of vegetable tissues) and examine at once. The following color contrasts will be observed.

1. The nuclei of the parenchyma cells and the nuclear fragments and shreds will be a bright greenish blue. The nucleoli will be a deeper blue than the rest of the nuclear substance.

2. The more or less completely dextrinized starch will be colored a bright blue.

3. The plasmic contents of mold hyphæ will be colored a bright though pale blue. Dead yeast cells, dead spores and dead mold hyphæ (dead before the time of processing) will remain unstained or will show coloration in proportion to the amount of plasmic substance which may have been present at the time of processing.

4. Living yeast cells and spores will be colored a bright blue.

5. The ducts and other lignified elements will be colored a very bright blue which coloration will gradually fade.

6. The walls of the fully ripened pulp cells will remain entirely free from color, thus forming a remarkable contrast with the stained elements. On the other hand, the green or immature pulp cells will show a bright blue coloration.

7. The nucleo-sphærocytes will show a somewhat dull greenish-yellowish coloration, which coloration developes rather slowly and is not very distinctive.

8. The plasmolyzed contents of the pulp cells remain practically unchanged.

The limited observations made would indicate that each special vegetable as well as animal substance will show its own peculiar contrast coloration with certain stains (with heat), and the color changes will furthermore, serve to convey valuable information as to the degree of decomposition, the proportion of ripe and unripe tissues, the degree of decomposition before and up to the time of final processing, etc. The entire field of hydrated (wet) tissue staining is unexplored. We have devoted overmuch time and effort to the staining of completely dehydrated tissues and tissue elements. Certain stains appear to be of little value in the contrast staining of hydrated tissues. For example, carbol-fuchsin is too diffuse in its effects. The use of the Broca differential stain with dehydrated tissues is not to be confused with the above. It would also appear that the use of metallic colloids, with certain acid and salt solutions will give rise to differential color changes in various tissues which may be of great diagnostic value in the study of food decompositions and in forensic medical investigations and criminal investigations. These color changes evidently have to do with colloidal activities (coagulation phenomena). The staining of hydrated tissues and tissue elements forms the connecting link between the comparatively little explored field of vital staining and the well known field of dehydrated tissue staining.

(*e*) **Recording and Interpreting the Findings.**—As soon as the microscopical examination is completed, the findings are recorded and interpreted and a recommendation is submitted as to what disposition should be made of the food substance.

(*f*) **Special Microbiological Methods in Food, Milk and Water Analysis.**—The following direct microbiological methods which have been used and are still in use, and are hereby reviewed very briefly. The field analyst will find most of them impracticable for routine purposes. Method (4) will be found especially useful.

1. *Water Analysis. Plankton Examination.*—V. Hensen applied the term plankton to the minute organisms and other organic matter drifting or floating in fresh and in salt water. In its more recent and more comprehensive appreciation the term includes bacteria and other microorganisms, and also dead organic matter and the very minute particles of mineral matter. In the more limited sense plankton excludes bacteria; although there is no satisfactory reason why this group of organisms should be omitted. The following methods have been used more or less.

(*a*) *Hassall Gravitation Method.*—Let two or three liters of the water to be examined stand in a tall vessel for twelve to twenty-four hours. Decant all but 200 cc. This remainder of 200 cc., with all sediment, is poured into a conical test glass with rounded bottom and set aside for six hours. Pour off the supernatant liquid and examine the small amount of sedimentary residue microscopically. In order to reduce to a minimum the growth of the contaminating organisms during the time interval above indicated, the containing vessels should be placed in an ice chest. The method is satisfactory as far as the estimation of inorganic and dead organic water contaminations are concerned, but is very unsatisfactory as far as the motile living contaminations are concerned.

(*b*) *MacDonald Gravitation Method.*—Into a vessel containing one to two liters of water, place a watch crystal, and let stand for twenty-four hours. Siphon off the water, carefully remove the watch crystal with the sediment, and examine microscopically. The deposit in the watch crystal represents the amount of material derived from a volume of water equal to the surface of the watch crystal times the height of the water column in the vessel.

(*c*) *Kean Sand Filtration Method.*—Run 100 cc. of water through a funnel with a sand plug (clean fine quartz sand). Wash the sand carrying the plankton into a watch crystal by means of 1 cc. of water and examine microscopically.

(*d*) *The Sedgwick-Rafter Method.*—This is a perfection of the Kean method and has been quite extensively employed in the United States. Sand of definite fineness is to be used and 250 cc. of the water are to run through the filter. A specially constructed counting chamber (50 × 20 × 1 mm., hence holding 1 cc. of the sediment) is to be used and the counting is to be done by means of a specially ruled micrometer scale and a 2/3 in. objective. Bacterial counting cannot be done by this method, neither can the smaller algæ and protozoa be accurately counted (for details see WHIPPLE'S WATER ANALYSIS).

(*e*) *The Dibdin Double Filtration Method.*—Run 1 liter of water through filter paper. Wash residue into a clay filter, made by plugging the drawn out end of a piece of combustion tubing with a mixture of baked clay and kieselguhr. Filtration is accomplished by means of suction. The sediment (plankton) forms a compact cylindrical layer in the tube and can be measured and the amount of the sediment per liter of the water stated. The sedimentary plug can then be removed and examined microscopically. This method likewise precludes the estimation of bacteria and also some other minute organisms.

(*f*) *Centrifugal Method.*—Centrifuge 10 to 50 cc. quantities of the water to be examined at a high rate of speed, so as to throw down all matter in suspension, inclusive of bacteria. Decant or pipette off all but about 1 cc. of the water, make up to 2 or 3 cc. by adding filtered distilled water, shake or mix thoroughly, and make the counts by means of a suitable counting chamber. Should actively motile organisms, such as paramecia, interfere with the counting, they may be killed by adding a drop or two of ether or chloroform, to the centrifuged material. For the purpose of examining and comparing a number of water samples at one operation, the Stewart-Slack centrifuge head will be found very convenient and time saving. Such special heads (holding twelve tubes) are provided for the small hand centrifuge which is elsewhere recommended for field work.

2. *Milk Analysis.*—There are three methods for the direct bacteriological examination of milk in use. Two or these require the use of the centrifuge. The direct microscopical examination of milk will convey information as to quality and purity which cannot be obtained through any of the chemical methods.

(*a*) *The Stewart-Slack Method.*—Two cc. of milk are placed into glass tubes which may be closed at both ends by means of suitable rubber stoppers. The special centrifuge heads made according to the specifications of Dr. Stewart of the Philadelphia Board of Health, will hold twelve to twenty-four such tubes. The tubes are then centrifuged at a speed of 2,000 to 3,000 revolutions per minute, for ten minutes. The sediment which has become more or less firmly fixed upon the stopper in the lower end of the tube, is mixed with a drop or two of water and smeared upon a slide, so as to cover about four square centimeters of space, allowed to dry and stained with methylene blue. The examination is made with the oil immersion objective and bacteria, pus cells and epithelial cells are counted.

(*b*) *The Doane-Buckley Method.*—Ten cc. of the milk is centrifuged for four minutes at a speed of 2,000 revolutions per minute. The fat is carefully removed; and the tubes again centrifuged for one minute more and the fat again carefully wiped away by means of a small cotton swab. Pipette off the supernatant fat free milk and mix the sediment with two drops of a saturated alcoholic solution of methylene blue. Let the stain act for a few minutes, hastened by warmth. Make up to the 1 cc. mark of the tube by adding water. Examine for body cells by means of the hemacytometer.

(*c*) *The Prescott-Breed Method.*—$\frac{1}{100}$ cc. of a thoroughly mixed sample of the milk is spread on a slide, within the ruled lines of just 1 sq. cm. The $\frac{1}{100}$ cc. of milk is measured by means of a special graduated capillary pipette. Both the pipettes and the ruled slides are to be had in the market. However, both can be made in the laboratory by any analyst having ordinary mechanical skill. The slide with the milk smear is set aside to air dry, fixed with alcohol, dipped several times into xylol to remove butter fat, and then stained with methylene blue or some other blood stain. The counting is done with the oil immersion lens, after having determined the area covered by the field of view. Estimations are made of the number of bacteria and body cells per cc. of the milk. This method is now employed in most food laboratories.

3. *Examination of Tomato Products.*—The industry of canning tomatoes has reached enormous proportions in the United States, within recent years. Some of the material placed in cans and offered in the market is of very inferior quality, being made from tomato refuse, trimmings and rotten tomatoes. Two methods of direct microscopical examination of these products are in use.

(*a*) *The Howard or Bureau of Chemistry Method.*—The method consists of three parts, as follows:

Mold Counting.—A bit of a well mixed and suitably diluted sample of the tomato product (as puree, catsup, sauce or paste) is placed on the special Howard mold counting chamber (depth 1/10 mm.) and covered with a thick cover glass. The counting is done by means of a low power objective (having a magnification of about 90 diameters), the draw tube being so adjusted that the diameter of the field of view is just 1.382 mm. (therefore the field will have an area of 1.50 sq. mm.).[1] Each field showing mold hyphæ ex-

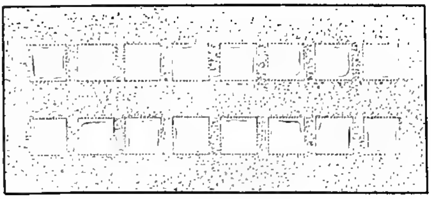

Fig. 22.

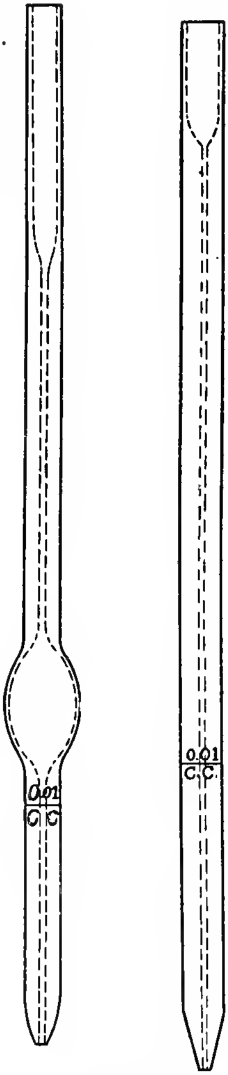

Fig. 23.

Fig. 22.—Guide plate for the bacteriological examination of milk according to the method of Prescott and Breed. The glass plate has sixteen 1 sq. cm. areas placed in two rows, the remainder of the surface being sand blasted. These areas are used as guides, being placed under the slide upon which the milk smears are made. ½ full size.—(*Made by the Bausch and Lomb Optical Company.*)

Fig. 23.—Bulb and straight capillary pipette for milk work according to the method of Prescott and Breed. Full size.—(*Made by the Bausch and Lomb Optical Company.*)

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[1] This method of making adjustment is somewhat faulty. In order that the different microscopes may have exactly the same counting values, the adjustment should

tending $\frac{1}{6}$ of the way across the field, or more, is counted positive. A tomato product is considered unsuitable for human consumption, if 66 per cent., or more, of the microscopic fields show mold.

Spore Counting.—The hemacytometer with medium power objective is used (magnification about 180 diameters). The spore count includes mold spores of all kinds and also the yeast cells, and the counts are indicated as so many per $\frac{1}{60}$ cmm. The present suggested numerical limit is 125 per $\frac{1}{60}$ cmm., or 7,500,000 per cc.

Bacterial Counting.—The hemacytometer, with objective giving a magnification of about 500 diameters, are used. Only the "rod shaped" bacteria are to be counted, it not being specified whether or not the very minute varieties and the diplobacillus forms are to be included. The present limit for rod shaped bacteria is 100,000,000 per cc. An earlier limit of 25,000,000 per cc. was abandoned, as very few manufacturers could comply with such a low limit.

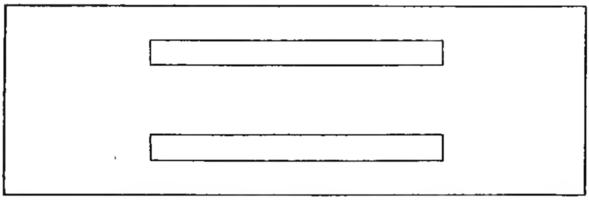

FIG. 24.—Special mold counting slide. The two glass slips upon the slide are just 0.1 mm. thick. The material of which the mold count is to be made is evenly spread between the two slips and covered with a thick rectangular cover glass. Full size. (*Made by the Spencer Lens Company.*) (*The Howard counting chamber is made by the B. and L. Op. Co.*)

Although not very specifically stated, it is generally understood and legally so interpreted, that the numerical limits for bacteria, spores, and mold, as specified under the Howard method, apply to catsups, there being no allowance made for either differences in concentration or in fineness of the tomato product.

The Howard method has been severely criticised for several reasons. As stated, it does not allow for differences in the consistency, nor for differences in the fineness of the pulp of the various tomato products, as puree, catsup, sauce and paste. Suitable and necessary definitions are wanting. The meaning of "debris" is not explained, and as a result, some analysts have condemned catsups

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be made as follows. Reduce all of the microscopes to the same magnifying power (90 diameters) by means of the drawtube and then adjust to the same field of view by moving the diaphragm of the eye-piece up or down as may be required to give a field having exactly 1.5 sq. mm. Or, the diaphragm of the eye-piece may require reaming out to make the required adjustment.

and pastes on the assumption that broken down (mechanically, as through finishing machines) pulp cells constituted debris. The fact that only rod shaped bacteria are counted has rendered bacterial counting as a routine method practically valueless, and the result of the count is in fact being left out as testimony in court proceedings. The facts are that the distinctively rod shaped organisms which occur in tomato products are largely of the group of lactic acid formers, which are essentially harmless; whereas many of the coccus forms, streptococcus forms, small diplobacillus forms, and the small bacillus forms, and to which groups belong many of the filth and sewage types, are far more objectionable. In the spore count, yeasts are included, which is certainly highly irrational as well as unscientific. An entirely different interpretation is to be placed upon these two groups of inclusions. The spores are traceable to mold and indicate contamination of tomatoes in the field, as a rule, while yeasts are traceable to defects in cannery methods. There is no reason why the spore count should be given per $\frac{1}{60}$ cmm. instead of per cc. One of the arguments in defense of the Howard method is that it is suited to the capabilities of the analysts employed in food laboratories. This argument may be countered by the statement that incompetent analysts have no place in any laboratory, least of all in a laboratory where matters affecting the public health are concerned. The Howard method is followed in the federal as well as in most state food laboratories.

(*b*) *General Laboratory Method for Tomato Products.*—Many food laboratories, not being satisfied with the Bureau of Chemistry method, employ modifications of this method in the examination of tomato products which modifications, as a rule, are more nearly in harmony with the methods applicable to the direct microscopical examination of other food products. Allowance is made for differences in concentration; certain spore types (as of Penicillium, of tomato black rot, of Fusarium, and a few others) are recognized; the yeasts and spore counts are recorded separately; hyphæ from field mold and from cannery mold are differentiated; the total bacterial count is recorded (including all bacillus forms, coccus forms, streptococcus forms, etc.). Generally an effort is made to reduce the pulp to a uniform degree of fineness by means of mortar and pestle or by rubbing through a fine mesh (No. 80) sieve. But most important of all, an attempt is made to give a rational interpretation of the microscopical findings in association with the organoleptic tests. The dilutions are made as may be required for more accurate counting, usually 1:5 or 1:10, rarely 1:100. The spore and yeast counts are given as so many per cc. instead as so many per 1/60 cmm. In making the mold counts of pastes, dilutions are used (1:2, 1:3, 1:5) and the degree of dilution always recorded with the analytical results. Debris (sand, dirt, insects and insect remnants, nematode larvæ calyx tissue, skin (epidermal) fragments, seed tissue fragments, core tissue fragments, mold clusters, moldy tissue fragments, etc., etc.) is reported and such findings properly interpreted. Differential stains are employed, especially in those tomato products (usually catsups and purees) which have been run through a finishing machine, for the purpose of differentiating between bacteria and non-bacterial fragments. Heed is given to sewage indicators, to contaminations traceable to filthy lug boxes and to unsanitary cannery methods; etc.; etc.

Several analysts have used the method employed in the direct examination of milks, in the examination of tomato products (Vincent and others). This is hardly necessary as the skilled analyst can, as a rule, obtain accurate results without the use of the more tedious and time consuming drying and staining method. The special staining method as hereafter given may be used for check purposes and in case of doubt.

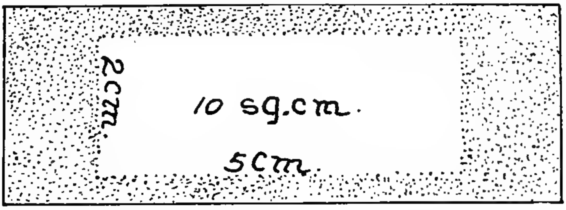

FIG. 25.—Guide plate and special slide for the bacteriological examination of milk and food substances generally. 0.1 cc. quantities are evenly spread upon the marked area. Full size.—(*Made by the Bausch and Lomb Optical Company.*)

4. *A General Laboratory Method for Making Direct Bacterial Counts.*—The following method will be found practically applicable in the direct microscopical examination of food substances of all kinds. Weigh (if solid or semi-solid) or measure (if sufficiently liquid to be poured) a definite amount of a well mixed average sample of the food substance, or drink, to be examined; dilute as may be desired (1 : 5, 1 : 10, 1 : 100); and make the counts by means of the hemacytometer (Turck ruling is most suitable, as bacteria, yeasts and spores can be counted in the same mount). This simple method will be found satisfactory with all food materials and drinks which contain little or no matter which might be confused with bacteria, yeasts and molds; such as water, sewage, tomato products and canned vegetables

generally, gelatines, glue, oils, some fats, syrups, extracts, centrifuged sediments, pathological secretions, broths, soups, etc.

If the food substance contains minute confusing bacteria-like particles which will make it difficult to use the hemacytometer in making the direct count, as milks, eggs, canned fish, meats, potted meats, sausages, canned fish and canned meats, shellfish, soup stocks, breads and pastry, frozen eggs and whole eggs mixed, dried milk, etc., then the following method is to be used. Deliver 1⁄10 cc. of the prepared and diluted substance upon a well cleaned (by means of alcohol) slide and spread this out over an area of 10 sq. cm. (2 cm. by 5 cm.), dry (upon a leveling table) at moderate temperature; add alcohol and again dry [remove fat and oil globules (if necessary) by dipping in gasoline, benzine or xylol, petroleum ether, etc.]; stain for one to three minutes with a drop or two of a 10 per cent. methylene blue solution (or Hoffman's violet, Broca stain, etc.); wash in water and, if desired, decolorize somewhat by means of acidulated alcohol (after which it must again be washed in water); dry at moderate temperature; and make the counts by means of the oil immersion lens (1⁄12 in.). The pipette used must be carefully graduated into tenths of one cc., and must have a free delivery in order that it may be used with substances containing granular matter in suspension. This is essentially a modification and generalization of the Prescott and Breed method as applied to the examination of milk, differing in that larger amounts are used (1⁄10 cc. instead of 1⁄100 cc.). It is impracticable to use the smaller amount in many cases, furthermore, the use of the larger amount results in a corresponding reduction or lessening in the source of error. The area of the field of view with the oil immersion lens must be carefully determined by means of the stage micrometer. The computation is simple. Let us suppose that the area of the field of view is 1⁄50 sq. mm., the dilution used is 1 : 100, and the average number of bacteria in one field of view is 30, then the total number of bacteria per cc., or per gram., would be 1,500,000,000 ($50 \times 30 \times 100 \times 1{,}000 \times 10 = 1{,}500{,}000{,}000$).

In all cases of doubt the staining methods should be given the preference, and in each and every case the organoleptic tests should be used, and both the microscopical findings and the evidences of the organoleptic tests should be intelligently interpreted.

For the staining method above outlined, special slides should be used. The surface should be etched, excepting the 2 mm. by 5 mm. (10 sq. mm.) area upon which the material is to be spread. The etched surface will make marking or numbering easy. Ordinary slides are however entirely satisfactory. The area may be determined by laying it over a piece of card board upon which the area boundary lines are carefully marked by means of pencil or India ink. Marking the field of view into quadrants will be a convenience in counting.

Substances deficient in albuminous matter for fixing purposes (on the thoroughly cleaned slide), should have added to them a small quantity of egg albumen. After the substance is drawn up into the pipette, and before delivery upon the slide, touch the delivery tip of the pipette upon a glass surface, and similarly touch the pipette upon the slide when the desired amount ($1/10$ cc.) shall have been delivered. Spreading must be carefully done, and the drying should be done at a moderate temperature and the slides must rest upon a level surface. Fifty fields of view should be carefully counted, selecting ten fields each from five approximately equidistant parts of the spread area. If the material spread upon the slide is dried too rapidly, it is apt to peel off in the subsequent manipulations; particularly is this likely to occur with milks.

As suggested elsewhere it is impracticable to lay down hard and fast rules as to staining, for the simple reason that no two workers employ the same minor details in laboratory technique and all workers differ as to speed and as to choice in the tools of manipulation. The following common stains are recommended for general use in bringing out differential characteristics.

1. *Loeffler's Methylene Blue.*—Mix 30 cc. of a saturated alcoholic solution of methylene blue with 100 cc. of a 0.1 per cent. aqueous solution of potassium hydrate. Filter.

2. *Ziehl's Carbol Fuchsin.*—Ten cc. of a saturated alcoholic solution of fuchsin; 5 grams of crystals of carbolic acid; distilled water 100 cc. Mix and filter.

3. *Broca's Differential Stain.*—To 80 cc. of the above methylene blue stain add 10 cc. of the carbol fuchsin. Mix and filter, use after having allowed it to stand for several days.

The Loeffler stain will be found most useful for general differential staining. The Ziehl stain will be found especially useful if it is known, or if it is suspected, that acid fast bacteria are present. It is a diffuse stain and calls for the careful use of some decolorizing agent, as acidulated alcohol. The Broca stain is especially recommended in cases where it is desirable to differentiate between dead and living bacteria (that is, dead or living at the time the stain was applied). In brief, the Loeffler stain will be used for routine purposes, and the others for occasional special purposes.

5. *Percentage Decomposition Determinations.*—Should the question arise as to the actual or comparative percentage of decomposition in a food substance, then the following general method should be uniformly followed, in order that the results of the tests made by different analysts may be uniform. Immediately after the count (as to bacteria yeasts and mold inclusive of spores) has been made, or just before, place ten cc. or ten gram quantities of the suitably comminuted substance under examination on clean and sterilized wire screens, or (if liquid) in flat dishes, and incubate at 37°*C.* for a period of five days, by which time the substance is completely decomposed, bacterially, and as to other organisms, as mold and yeast. Make the counts of this decomposed material in the usual manner, and compare the results with those of the first count, and from such comparison deduce the percentage or degree of decomposition. We will suppose that the original examination of a fruit product gave the following counts.

A Fruit Product

Total bacteria	250,000,000 per cc.
Total yeasts	40,000,000 per cc.
Fragments of mold hyphæ	50,000 per cc.

After a sample of the original fruit product has been incubated as above directed, it has to all intents and purposes undergone complete decomposition and may be represented by the following counts.

Completely Decomposed Product

Total bacteria	3,000,000,000 per cc.
Total yeasts	150,000,000 per cc.
Mold hypbæ	2,000,000,000 per cc.

Since a substance cannot be decomposed 300 per cent., as might be supposed from the above, we must add the three percentage values and divide by three. Considering first the bacterial counts, we find that $^{25}/_{300}$ times 100 per cent. equals 8.3 per cent. (that is, 250,000,000 : 3,000,000,000, :: x per cent. : 100 per cent). As to the yeast counts we have $^{4}/_{15}$ times 100 per cent. or 26.6 per cent. The mold count in the original as compared with the completely decomposed material is negligible, amounting to a very small fraction of 1 per cent., and may be considered as zero. Then, $8.3 + 26.6 + 0 \div 3 = 11.6$ per cent. decomposition of the fruit product under consideration, of which yeast decomposition was preponderant. A meat product may show 5,000,000,000 bacteria per gram whereas the completely decomposed meat (treated as above directed) may reveal 60,000,000,000 bacteria per gram, the meat under consideration was therefore decomposed 8.3 per cent. Each food product manifests its peculiar decompositions and the estimates which may be obtained in the manner above outlined give comparative results only. It must also be kept in mind that complete decomposition of food substances as usually comprehended is not to be confused with complete putrefaction of animal matter or complete rotting of vegetable matter. A food substance is usually considered completely decomposed when every part of it is clearly and distinctively spoiled, not any part or portion of it being undecomposed or wholesome. After the food article has undergone this complete or 100 per cent. spoilage or decomposition, it continues in the decomposition changes until it is completely putrefied or rotted. It is impossible to say where the one change ends and the other begins. Food analysts are not interested in the ordinary changes of rotting or putrefaction, nor is it of any special practical value to know the percentage of decomposition; however, it is occasionally desirable to present such data in court proceedings. It does not appear practicable to rate the quality of food upon a percentage of actual decomposition, according to the method above outlined. Such a method could, however, be made to have much practical significance, provided it was uniformly applied by all analysts. It must be kept in mind that the decomposition changes in foods are influenced by the preparations to which they have been subjected and the additions made thereto, as has already been explained. The decomposition changes in untreated meats are quantitatively as well as qualitatively different from those of spiced and salted sausage meats or sausages. Furthermore, the analyst must bear in mind that food substances to which large amounts of preservatives are added, will not decompose or decompose comparatively slowly. Thus the total decomposition during the incubation period of five days would vary not only as to the kind of food but also as to the preparation and treatment of the same kind of food.

The rate of decomposition is proportionate to the surface exposure of the substance and the supply of atmospheric oxygen and also moisture which is admitted thereto. In making the decomposition tests as above indicated it would be highly desirable for the analysts to agree upon a maximum size of the food particles to be incubated, in order that decomposition may be complete as above defined, within the incubation period of five days. Furthermore, the pieces of the food substance should be evenly spread upon a wire screen to a depth of about 5 mm., in order that there may be free exposure to air, which should be admitted into the incubator by way of suitably placed ventilators, and the atmosphere should be kept moist (saturated). If the food substance is a liquid or semiliquid, such as milk, soup, broth, soup stock, catsup, etc., it should be poured into flat dishes (the halves of Petri dishes are ideal for this purpose) to a depth of about 5 mm. The exposed food substances should be stirred once or twice a day. It need scarcely be adviced that the decomposition incubator should be placed under a hood so as to allow the bad odors to escape into the open.

Army and navy food analysts are not interested in tests of the kind suggested. It will frequently interest judge, jury and opposing attorneys, in proceedings under the pure food and drugs acts, federal as well as state. This interest is prompted by the phraseology in the law which reads as follows. "A food shall be deemed adulterated, if it consists in whole or in part of a filthy, decomposed, or putrid animal or vegetable substance, or any portion of an animal unfit for food, whether manufactured or not, or if it be the product of a diseased animal, or one that has died otherwise than by slaughter." This paragraph of the federal act (Sec. 7) is particularly clear and definite.

6. *Microscopic Test for Heated Milk.*—In heated milk (boiled or Pasteurized) the fat globules are more or less agglutinated; that is, from two to five globules may be stuck together making it more or less difficult to recognize the individual globules. The outline of the globules is also less regular, being somewhat angular.

The body cells (epithelial and endothelial cells, and inclusive of leucocytes and pus cells) of heated milk, stain much more readily than do similar cells in raw milk. Add one part of methylene blue (10 per cent. aqueous solution) to three parts of the milk, drop by drop with constant stirring to prevent coagulation (a trace of a 10 per cent. sodic hydrate solution will be useful). Let stand for from ten to twenty minutes and examine. If the cells, more especially the nuclei, are stained, the milk has been heated.

7. *The Microscopical Examination of Butter, Oleomargarine and Fats.*—Animal fats show abundant fat crystals which differ in size and in grouping. Beef fat crystals are short, with abundant radiate clusters. The fat crystals of the feathered animals are among the longest. Lard crystals are longer than those of beef fat. Pure butter shows no crystals. Vegetable fats generally show abundant crystals.

(*a*) *Butter.*—Mount a bit of the butter on a slide and spread out under the cover glass and examine under the polarizer, using a low power. With the selenite plate, pure butter will show a uniformly blue field (with the blue selenite plate) when the Nicols are crossed. Salted butter may show a few salt crystals but no fat crystals. Examine under a high power, without the polarizer, and note the water globules. "Stretched" or watered butter will show such globules in great numbers.

Cholesterol crystals may be developed as follows. Place a bit of the butter in a test tube, and add from 10 to 15 cc. of ether and let stand for 24 hours at a temperature of from 20° to 25°C. Remove the crystals which will be at the bottom of the test tube by means of a small pipette and examine them under the high power.

(*b*) *Oleomargarine.*—Mount and examine as for butter. Fat crystals will be found abundantly present and under the selenite plate the field will remain uncolored when the Nicols are crossed. If butter has been added then isolated spots and areas will be shown with blue or bluish color.

(*c*) *Cocoa Butter.*—Mount and examine as for butter. Under the polarizer with the selenite plate, there is the same coloring as for butter, but the entire field will be filled with small acicular crystals.

Phytosteral crystals may be developed as for cholesterol crystals and similarly examined.

It should be borne in mind that the empty field of the microscope also shows a blue field with the polarizer and selenite plate.

8. *Examining Food Substances for Broken Glass.*—One of the most remarkable crazes which originated among civilians of the United States during the World War, was the notion that broken glass was added to flours, breads, sugar and other food stuffs. For a time a considerable number of the entire personnel of the food laboratories were kept busy examining materials which were suspected to contain broken or powdered glass. Of the thousands upon thousands of food products that were examined for broken glass not one was ever found which actually contained this substance. The suspicion was found to be either entirely groundless, or the suspected material proved to be a trace of sand, of pebbles and in a number of instances, granulated sugar. The following simple test will reveal the presence of glass in food substances of all kinds.

Separate the gritty particles supposed to be glass from the food substance by sedimentation and elutriation. If the granules which have been obtained in this manner are coarse, they may be reduced in a mortar. Mount a bit of the powder in water and examine under the polarizer. Rotating the Nicols produces no play of colors in glass, whereas sand particles will show an interesting play of colors. Interposing the selenite plate (blue and yellow) produces no change other than the uniform bluing and yellowing of the entire field, as with butter, cocoa butter and the empty field.

Many food substances contain more or less sand. Dried foods (those dried in the open, exposed to wind and weather), as dried apples, dried peaches, dried apricots, and others, usually contain enough sand as to necessitate careful washing and rinsing before cooking. String beans, canned spinach and other vegetables may contain some sand.

9. *A General Method for Making Approximate Quantitative Microanalyses.*—The following method is added for the sake of completeness and because of its special value in civilian laboratories. The army microanalyst will have little time or opportunity to make use of it. Time and opportunity may be found to make application of the suggestions given, at the base laboratories, should such laboratories be established.

The method is applicable to many widely different substances, as spices, meals, flours, powdered substances of all kinds, tobaccos, etc. The question may arise as to the percentage of shells in ground black pepper, in cloves, in cocoa or chocolate; the amount of cereal in sausage, of starch in ice cream, of ground olive pits in some ground spice or powdered drug. The method applies to problems of adulteration, primarily, and not to questions of food decomposition.

Several special microanalytical methods (qualitative as well as quantitative) have already been given. Attempts have been made from time to time to develop quantitative microanalytical methods which might be generally applicable, notably by Chamot, Meyer, Hanausek, Weinzierl, König, Vogel and others. These quantitative methods are largely based upon the fact that certain tissues and tissue elements are quantitatively fairly constant in plant organs and plant parts and in the various manufactured plant products found upon the market. For example, mature ginger contains a fairly definite percentage of starch, whereas the immature ginger contains far less starch. Green apples contain considerable starch whereas ripe apples contain only a trace of starch. Belladonna roots gathered too early in the season are deficient in starch. Old thick cinnamon bark is deficient in bast. Cloves contain no sclerenchyma cells whereas clove stems are rich in this tissue. The chief difficulty in the way of formulating definite working methods, is the lack of available analytical data upon which to base such methods. For, example, if we had a record of the starch content of ginger, of the apple, of belladonna root, of aconite root, of colchicum corm, etc., for each month of the growing season, then we could readily use the starch factor in determining the percentage of the articles gathered green or too early in the season. If we had a complete morphologically descriptive record of the development of the pollen grains in the insect flowers, we would then be in position to determine quantitatively the amount of overripe flowers used in a given insect powder. In other instances it is possible to determine on the spot the necessary data for each quantitative analysis; as for example in the estimation of the percentage of stems in cloves, the percentage of black pepper refuse in black pepper, the percentage of stems in senna leaves, etc. Patience and a willingness to work are the essentials to success in the working out such methods. As the details for the quantitative microanalysis of any one vegetable substance are fully and accurately worked out, the figures obtained should be carefully and permanently recorded for the benefit of those who follow after.

The chief source of error in making quantitative microanalytical determinations, of the kind here described, is the fact that while the different tissue elements and cell contents are fairly constant in tissues of the same kind (in the same relative position and of the same age and seasonal growth), we have no usable records of the quantitative tissue variations in plants, more especially in the perennials. For example, how does the bast, sclerenchyma and bark parenchyma in the bark of the white oak vary from year to year, not only in the trunk of the tree but also in the branches? Such a study would be of great value in the practical application of the method in the examination of cinnamon barks, sassafras bark, wild cherry bark, cascara bark and barks in general. What is the annual increase in fibrous tissues in belladonna roots? What is the relative amount of fibrous tissues in the wild growing and in the cultivated chicory? What is the relative amount of fibrous tissues in trimmed licorice roots and in the licorice trimmings? What is the exact quantitative relationship of like tissues in the inner and outer barks of the same species of trees? Since such data are not available, they must be carefully ascertained for each individual case or problem and the figures carefully recorded.

At best any quantitative microanalytical methods which may be worked out, will give approximate results only, however, these approximate results are sufficiently accurate for all practical purposes. The chief factors in the variation of results are dependent upon the fact that the tissue elements and cell constituents vary (in different vegetable substances of the same kind gathered at the same time) in proportion to the size of the plant part or plant organ. This difference amounts to but very little in average commercial articles of the same kind and may in fact be wholly ignored. The chief reason why the microanalytical methods should be developed is because this is frequently the only method which will give the information desired, the chemical methods being wholly inapplicable.

The following general method is given with the hope that it will serve as a basis for a further development of this most important addition to the analytical methods employed in food and drug laboratories.

1. *Selecting the Sample.*—Secure an average commercial sample of the crude drug or spice, free from impurities. Great care must be observed in selecting and preparing an average sample. It should be a true average ample of the commercial article of recognized standard quality or grade, as defined by the Department of Agriculture, Bureau of Chemistry, or in case the article is not defined or described by the Bureau of Chemistry, it must be of the quality and grade generally recognized in commerce, or as described or defined in recognizedly authoritative works of reference. Foreign inclusions, as vegetable tissues, dirt, clay, sand, pebbles, etc., must be removed by any suitable method, provided, that none of the substance of the article itself is thereby removed or destroyed or rendered unrecognizable. Enough of the material must be taken to assure an average sample for analytical purposes.

In order to be able to select an average or representative sample of the commercial article, considerable experience is necessary. Spice dealers are, as a rule, excellent judges of the quality of the products to which they have given years of close observation. The wholesale drug dealers are thoroughly familiar with the appearance of the crude drugs as they are offered on the market. Grain merchants can, at a glance, determine the grades of the various cereals. Tea experts will recognize aromas and flavors entirely lost to the inexperienced observer. Fortunately, it is not expert ability which is required to select a representative sample, but rather a familiarity with a fair quality or grade of the articles to be examined. If, for example, it is desired to examine ground black pepper as to the approximate percentage of pepper hulls present, the comparison is to be made with a fair quality of whole black pepper, not with so-called "grinding peppers," or peppers otherwise defective, or with some special commercial variety or blend of black pepper. Before grinding, all sand dirt, pepper stems, and markedly defective fruits, must be removed. Considerable care must be observed in selecting an average sample of a root drug or of a drug composed of roots and rhizomes, or of leaves and stems. It is necessary to have on hand carefully selected average samples of drugs, spices, cereals, coffees, teas, cocoas, etc., inclusive of the various refuse tissues and the various milling by-products, as well as articles commonly employed as adulterants, such as nut shells, olive pits, tea dust, coconut shells, screenings and tailings, refuse and trimmings, colocynth seeds and rind, corn cobs, corn silk, bran and middlings, cereal chaff, wild mace, wild nutmeg, chicory, male fern chaff, tobacco stems, senna stems, senna siftings, roots of *Ruellia ciliosa*, false senega, pokeroot, etc., etc.

2. *Grinding or Powdering the Sample.*—After the average sample has been garbled, cleaned and thoroughly dried, it is reduced to a No. 80 powder, inclusive of all tissues which may be present. In some instances it will be found necessary to reduce the material to be examined and compared, to a much greater fineness, in a special mill or a mortar. In order to make accurate starch counting possible the starch bearing tissue must be made sufficiently fine to pass through a 200 mesh sieve or through bolting cloth. In other instances certain tissues may be removed and separated in comparative purity by means of very coarse mesh sieves (Nos. 8, 20, 40). In this manner such substances as bran, crude fiber, coarser meals, shells, etc., may be separated from the finer elements and their percentage values determined separately, as will be explained.

3. *Mixing the Powdered Sample.*—After the grinding, the entire amount must be thoroughly mixed by means of a spatula. Shaking in a container is not satisfactory. If the amount of the material is considerable (20 grams and more), divide the thoroughly mixed material (spread out in a circular layer) into quadrants, remove one quadrant and again mix this thoroughly by means of a suitable spatula. A second division may be made if necessary. The final sample should be not less than five grams.

4. *Making the Diluted Suspension.*—Dry the thoroughly mixed sample for one hour at a temperature of 80°C. Weigh out five grams of the sample and place it in a 25 cc. graduated cylinder, add 10 cc. of distilled water (or 10 cc. of a mixture of equal parts of distilled water and glycerin) and mix thoroughly by means of a glass rod. Fill up to the 25 cc. mark with a three per cent. gum acacia solution and again throughly mix. The gum solution will hold the tissues in suspension until the microscopic examination is made. The above makes a dilution of 1–5 which will be found

satisfactory in most cases. Higher dilutions, as 1:10, 1:25, 1:100 may be used if desired or if necessary for accurate results, as in starch counting.

Other suspending media may be used, as glycerin, a thin syrup, solution of cherry gum, solution of gum mastic, gelatin solution, India gum solution, etc. It is advised to stir the material in a little water first, as stated above, for if the gum solution should be added at once, considerable difficulty may be encountered in getting minute particles, starch granules in particular, evenly distributed. It is of course necessary to stir and mix the suspension thoroughly each time a new amount is to be made.

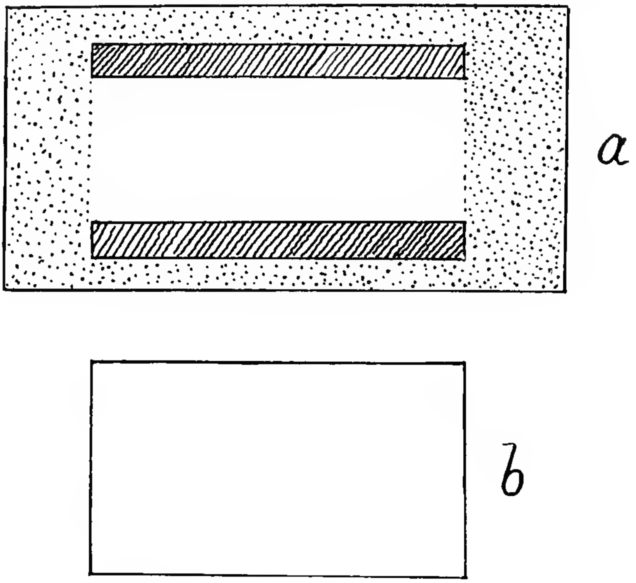

FIG. 26.—Special counting chamber for making quantitative microanalyses of foods, spices and drugs. The two glass slips upon the extra size slide are just 0.2 mm. thick and the area bounded on two sides by the two slips is just 10 sq. cm. (1,000 sq. mm.). 0.2 cc. suspensions of the material to be examined is spread in this area and covered with the rectangular cover glass (*b*). Full size. (*Made by the Bausch and Lomb Optical Company.*)

5. *Making the Counts.*—The mounts must be made without a time lapse in the entire procedure. Immediately after the thorough mixing, take up from 0.5 cc. to 1.00 cc. of the material by means of a graduated straight cylinder pipette, having a free outflow (1 cc. or 2 cc. pipettes graduated into tenths), reject 0.1 to 0.2 cc. and then deliver just 0.2 cc. upon the counting chamber or counting slide and at once mix and spread this out between the two slips on the slide (use a platinum loop or needle, or any blunt needle, or a

very thin glass rod), and cover with the special rectangular cover glass, by placing the proximal end of the cover at the distal ends of the two slips, pushing it forward upon the two slips, lying flat upon them. If the exact amount indicated (namely, 0.2 cc.) has been properly spread and the cover glass carefully placed, the entire space between the two slips and the cover glass will be occupied by the material without any excess or overflow. The mount should be set aside on a leveling table for a few minutes, otherwise starch granules may become unevenly deposited by the force of gravity.

If the powders to be examined are very fine, as starches and some meals, face powders, dusting powders, etc., the counts may be made by means of the hemacytometer, instead of the above special counting chamber. A number 80 powder does not permit the use of the hemacytometer for counting. It is perhaps self evident that actual numerical determinations per cc. or per gram may be made by means of the method just outlined, since definite quantities and definite counting areas are used.

If it is desired to make careful starch counts of drugs and spices, it is necessary to use a higher degree of fineness. The particles must be small enough to pass through a 200 mesh sieve or through bolting cloth. In the case of vegetable substances having starch aggregates, it is advised to count the aggregates as one, rather than to attempt to give the number of individual granules in each aggregate, as for example in making starch counts of oat, rice, aconite and buckwheat, but care must be observed not to omit to state this in the recorded results.

In the above method it is not necessary to give any attention to differences in specific gravity of the different tissue elements and cell contents. Should it be desired to give the percentage of sand present (by weight) in a given vegetable powder, it would be necessary to ascertain by the trial method that mixture of the substance and sand which would give the same counts as the article under examination. Let us assume that by the trial method we found that the addition of 5 grams of sand to 5 grams of the powder we obtained the same sand count as in the substance under examination, then we would know that the sand adulteration amounted to 50 per cent. However, in the case of sand adulteration, the simpler and almost equally accurate beaker or test tube sand test will be employed, rather than the microscope.

The depth of the mount, namely 0.2 mm., requires good working distance of the compound microscope in order that the entire depth may be brought into view. The cover glass used must be thin, not to exceed the thickness of the ordinary No. 2 covers. The usual lense combination (ocular and objective) giving a magnification of about 450 to 500 diameters may be used. A good observer who is entirely familiar with tissues and tissue elements could use a lower magnification with better effect, such as a well corrected combination giving a magnification of about 180 diameters.

The procedure is as follows. Carefully examine each and every separate and distinct field, counting all of the characteristic tissue elements and record the findings numerically. The mechanical stage will be of advantage in shifting the counting chamber. It will be found that from thirty to fifty distinct fields can be counted in one mount. The averages of not less than fifty counts should be taken upon which to base the percentage estimates of quality or adulteration.

Before beginning the counts, it is advisable to look the mount over under the low power (about 90 diameters) for the purpose of ascertaining whether or not the material is uniformly distributed. If it is unevenly spread, a new mount should be made. In fact, the low power alone is used in examining some substances, as for example Cinchona bark, the identity and purity determinations of which are based upon the counting of the characteristic large bast elements. Difficulty may be encountered in getting the total counts of aggregates of cells, as bast and sclerenchyma. As a rule, however, in a number 80 powder, aggregates which are so large as to make counting difficult, are rare. Some investigators have suggested that the quantitative estimates should be based upon the actual measurements of cells and cell contents. This is not necessary, as the average of the numerical count is fully as accurate as the average based upon measurement. However, as already indicated, where identity depends upon differences in size, then measurements (linear) must be made.

It is necessary that the same microscope and the same objectives and ocular be used at all times, in order that the results may be relatively uniform. For instance, should a partial count be made with one instrument, and completed with another instrument, even if approximately of the magnifying power, the results would be inaccurate. In order that work of different analysis may be unified, it is necessary to adopt standard methods. The surface area of the field of view of each microscope used must be accurately determined by means of the stage micrometer. The Bureau of Chemistry method for the examination of tomato products directs that the field of view be unified by means of the draw tube, so that each field shall equal 1.50 sq. mm. (diameter of field of view equals 1.382 mm., therefore, area of field equals 1.50 sq. mm.). This method is faulty because no allowance is made for the differences in magnification of the microscopes used. Proper adjustment of this kind should be made by means of the ocular diaphragm, after having reduced the microscopes to the same magnification by means of the draw tube. Accurate comparative results may be obtained by any number of analysts provided a counting chamber of definite area be used. The special counting chamber recommended has a depth of 0.2 mm., the total contents of the entire area being 0.2 cc.

6. *Making the Comparisons.*—In the identical manner as above set forth (1 to 5 inclusive), prepare and examine the article to be compared and of which the quality or purity is to be determined. From a comparison of the two averages of counts thus obtained, it is possible to determine the approximate percentage of admixture and adulteration. Let us suppose that the article in question was Cassia cinnamon and the average counts were as follows.

The standard cinnamon		The compared cinnamon
Bast cells	2.5	0.8
Sclerenchyma cells	12.1	14.0
Starch granules	50.0	13.0

The most diagnostic tissue of cinnamon is the bast and if we use this count alone (2.5 : 0.8 :: 100 per cent. : x per cent.) the conclusion would be drawn that the article in question was 32 per cent. adulterated or 32 per cent. below a good or standard quality of cassia cinnamon. The other counts (sclerenchyma and starch) are corroborative. The bark parenchyma count is not given because the microscopic appearance of this tissue is non-characteristic, the cells being much broken up making counting difficult if not impossible. The odor of the compared article was musty and the taste quite feeble. The conclusion based upon the organoleptic tests alone is that the article in question is of very inferior quality made from old bark and that adulteration amounts to over 30 per cent.

Standard insect powder		Compared insect powder
Pollen grains	5.4	0.2
T-shaped or spindling hairs	2.0	2.1
Sclerenchyma cells	10.0	0.6
Fibrous tissue	8.0	60.0

The findings would indicate that the article in question was 100 per cent. adulterated and that the adulterant was Pyrethrum stems. The small amount of pollen found in the compared article may be wholly ignored as that amount of pollen is normally present in and upon leaf and stem tissue, even though no flowers are present. A so-called insect powder may show abundant pollen grains and yet be 100 per cent. adulterated, as when foreign flowers are used, hence the analyst must be able to recognize different pollens.

Sample powered cloves		Clove stems
Bast cells of clove stems	6.0	10.0
Sclerenchyma cells	12.0	21.0

In the above example the comparison is made with pure clove stems, which article is the most common adulterant of powdered cloves and in this case the two tissues, namely bast and sclerenchyma, are present in fairly constant ratio, hence both counts may be used and should check each other, if carefully made. The double proportion would be 10 : 6 :: 21 : 12 :: 100 per cent. : x per cent. $10x = 600 = 60$ per cent. $21x = 1200 = 58$ per cent. Under the law (federal pure food and drugs act) 5 per cent. of stems are allowed. Sixty per cent. less 5 per cent. leaves 55 per cent. unlawful adulteration in this case. In this case the average of 60 per cent. and of 58 per cent., namely, 59 per cent. should be taken.

Sample cocoa		Cocoa stems
Fragments of spiral ducts	3.8	13.9
Sclerenchyma cells	2.6	10.0

The spiral ducts are most readily recognized and are fully as diagnostic as the sclerenchyma cells. Both tissue elements should be included in the counts and the average of the two percentages obtained should be used. Thus, 13.9 : 3.8 :: 10.0 : 2.6 :: 100 per cent. : x per cent. $13.9x = 380 = 20.1$ per cent., and $10x = 260 = 26$ per cent. $20.1 + 26 \div 2 = 23.05$ per cent. of shells in the cocoa under examination. Under the law 3.50 per cent. of shells (called "crude fiber") is allowed, hence in the above case we have $23.05 - 3.50 = 19.55$ per cent. of excess of shells or crude fiber. The starch count is of little value because this substance is present in small amounts and is furthermore quite variable in amount in the different varieties of cocoa. The endosperm cell count is impracticable because the cells are very much broken up. The amount of vascular elements (represented by spiral ducts) and of sclerenchyma cells is negligible in absolutely pure (wholly freed from shells by hand) cocoa and chocolate.

In the case of aconite root, belladonna root, colchicum corm, ginger, and other plant structures rich in starch, a careful starch count would indicate whether or not the article was gathered out of season or before maturity. In the case of leaves and herbs which contain distinctive trichomes, as senna, digitalis, artemisia, etc., these structures would serve as the basis for percentage determinations. In other cases measurements (relative size of starches in Rio and Carthagena ipecacs, relative lengths of trichomes in India and African senna) must be resorted to in order to determine percentage admixtures.

In many instances it may not be necessary or even desirable to reduce the substance to uniform fineness. In a compound, as cattle, chicken or condition powder, one or more of the components (as bran, crude fiber, sulphur, charcoal, meals) may be separated in comparative purity by means of the nest of sieves; the several coarse and comparatively pure components are weighed and their percentage values finally computed. The finer components are mixed and reduced to the desired fineness for making the microscopic counts as already explained, and the results added to those obtained by the sifting process. The following will serve as an illustration of the method of procedure:

A condition powder, using ten grams of a well-mixed sample.

Total weight of sample	10.0 grams
Bran, on coarse mesh	2.3 grams
Corn meal, on next finer mesh	3.6 grams
Finer remainder, on No. 60 mesh	4.1 grams

The finer remainder reduced to a No. 200 mesh powder and examined microscopically gave the following counts (one gram of the powder suspended in 99 cc. of the gum solution).

Corn starch	51,000,000 per gram
Wheat starch	8,000,000 per gram
Sulphur particles	13,000,000 per gram
Charcoal particles	32,000,000 per gram
Wheat tissue elements	800,000 per gram

In the above counts the corn starch count is to be interpreted in terms of corn meal, as no corn starch was added as such. The wheat starch count and crude fiber of wheat is to be interpreted as wheat middlings. The percentages of sulphur and of charcoal are determined by the actual trial method. The following is the reconstructed formula of the condition powder, based upon the above data.

CONDITION POWDER

Wheat bran	25 per cent.
Wheat middlings	15 per cent.
Corn meal	40 per cent.
Sulphur	10 per cent.
Charcoal	10 per cent.
Total	100 per cent.

Corn meal reduced to a fineness so as to make a count of the total starch granules possible gives 1,305,000,000 granules per gram. The starch content of wheat middlings varies considerably, but an average article will give a starch count of 200,000,000 granules per gram. One gram of sulphur will show about 140,000,000 particles per gram. The number of charcoal particles per gram will depend upon the degree of fineness. In the above about 350,000,000 per gram. From these figures it is simple to deduce the formula given.

The experienced microanalyst can estimate percentages with some degree of accuracy by optical judgment, but such estimates will not be acceptible in court proceedings. Thus, based upon the inspection of an ordinary slide mount, certain face powders are declared to contain about 3 per cent. of rice starch or corn starch, so-called arrowroot biscuits show about 2 to 2½ per cent. of arrowroot starch, a pancake flour is estimated to contain 25 per cent. buckwheat and 75 per cent. wheat flour; a baking powder is estimated to contain 25 per cent. corn starch, etc. This is the only method possible in cases where the amount of the material is too small to permit the use of definitely weighed amounts or definite volumes. This is clearly illustrated in the following rather extreme and highly complex example. A bit of vomit smear on a small piece of newspaper was submitted by a physician with the explanation that it represented a medicinal substance of which he desired to know the composition. A careful microscopical examination of the smear revealed the following ingredients.

1. Starch granules and the bast cells derived from the peeled roots of *Althaea officinalis.*
2. Papillose epidermal cells with red coloring matter of the petals of the red rose.
3. Abundant globules of metallic mercury.
4. Numerous chalk particles.
5. A few pollen grains.
6. Crystals of calomel.
7. Abundant crystals of basic mercuric sulphate (turpeth mineral).
8. The starch granules, yellow lignified fibers and the crystal bearing fibers of *Glycyrrhiza glabra.*

As has been stated in Part I, one of the most important requirements or qualifications on the part of the microanalyst, is the ability to interpret the finding intelligently and correctly. The above findings are not numerous nor were they difficult to recognize. The interpretation proved very interesting, as follows:

(*a*) Confection of Rose, U. S. P., indicated by (2) and (5). Turning to the Pharmacopœia, the formula for confection of rose was copied.

Red rose petals (No. 60 powder)	80 grams
Sugar	640 grams
Clarified honey	120 grams
Stronger rose water	160 cc.

(*b*) Blue mass, U. S. P., indicated by (1), (3) and (8).

Mercury	35 grams
Licorice powder	5 grams
Althaea powder	25 grams
Glycerin	33 cc.
Honey of rose	34 cc.

(*c*) Gray powder, U. S. P., indicated by (3), (4) and (5).

Mercury	38 grams
Clarified honey	10 grams
Prepared chalk	57 grams
Water, ad	100 grams

(*d*) Calomel.

(*f*) Turpeth mineral.

Based upon the optical appearance of the several ingredients of the smear as seen under the microscope, assisted by a number of trial combinations which were compared with the smear (microscopically), the following was given as the formula of the medicinal substance represented by the material upon the bit of newspaper.

Reconstructed formula based upon the above.

Confection of rose, U. S. P.	8 parts
Blue mass, U. S. P.	12 parts
Gray powder, U. S. P.	35 parts
Calomel	15 parts
Turpeth mineral	30 parts

Naturally, problems of the kind just illustrated require much time and careful study, and as already indicated, much experience in the practical use of the compound microscope.

3. Indirect Methods

Numerical determinations of bacteria and mold in foods may be made by other than the direct methods just described.

(*a*) **Plating Methods.**—Estimating the number of living bacteria in foods by planting definite amounts of the food substances into plates (Petri dishes) containing the required culture media, is a well-known and standard procedure. This method will be but rarely employed by the field microanalyst for the reason that time and suitable laboratory facilities are usually lacking, and also for the reason that the results from such methods would add little of practical significance or value to the information which may be gained through direct microscopical examination. In many instances the plating methods would prove wholly negative, even in the presence of advanced decomposition changes, as in canned tainted fish and meats, where the rotting organisms which were active prior to processing, are all killed by the processing temperature.

(*b*) **Tube Cultures.**—Tube cultures (plain and fermentation) may be desirable and necessary occasionally. In the routine field work they are inadmissible, because the necessary equipment is not available. The vital incubator has already been referred to. Tube cultures referable to sewage contaminated water, milk; typhoid contamination, cholera contamination, etc., must be made at the laboratory (hospital base, or motor laboratory).

(*c*) **Quality Tests.**—These are legion and pertain to foods as well as to beverages. Quality determinations may be based upon organoleptic tests, microscopical examination and animal feeding tests. Good judgment and experience are the essential requirements on the part of the analyst. It would be impracticable to set forth in detail the methods, the ways, and the means, for making the quality tests. In one instance the sense of taste may determine the lowered or lessened quality of a prepared dish or food, due to lack of seasoning or to overseasoning; again the odor may indicate incipient decomposition changes in meats. The consistency and color of the meat may indicate ante-mortem disease, over-storing, etc. The microscope reveals many forms of food inferiorities. It is notable that such animals as cats, dogs, and even hens, are far better judges of some food qualities than are humans. If the cat or dog refuses, or eats hesitatingly or with some reluctance, a food which is usually eaten without hesitation, such food should be looked upon with suspicion.

(*d*) **Feeding Tests.**—A food suspected of being poisonous (added poisons, such as arsenic, strychnine, and other vegetable alkaloids, poisonous plants as aconite, belladonna, deadly nightshade, etc.), or of containing ptomaines, toxins and toxalbumins of microbic origin, should be tested on some available animal. Supposedly toxic meats might be fed to dogs or cats, or to the omnivorous domestic fowl. Even ducks may be employed for such tests, although this animal is comparatively immune to some poisons. It is quite susceptible to the poison of botulism. Supposedly toxic vegetable substances may be experimentally fed to rabbits, or guinea pigs. Frogs may be employed.

All food supplies found or taken in enemy territory, or left by the enemy, or taken from the enemy, is or should be looked upon with suspicion and should be carefully examined. Poisoning of food supplies by military authority appears to be rarely if ever practiced, but the possibility of food being poisoned by some irresponsible enemy, should not be overlooked. The rule is, in case of urgency, as impending invasion or capture by enemy, to either hide the food stores or to destroy them, rather than to poison and leave them. It should also be kept in mind that food stores abandoned by enemy may have spoiled through exposure and long storage. In brief, all food supplies taken from enemy or found in enemy territory, should be carefully examined before using.

4. Special Methods

The following suggestions on special methods will prove useful in the field work as well as in hospital or base laboratories. While most of the food work is done by means of the hand portable equipment already referred to, there are certain analyses and investigations, which require a more elaborate equipment. The motor laboratory, properly equipped, will meet all requirements.

(*a*) **Water Analysis.**—Water and food are the absolute essentials to life, and of these two, water is perhaps the more important. The water supply must be ample and must be of good quality. Water for drinking, cooking, washing and bathing purposes, must be free from infections or other objectionable ingredients. The water supplies intended for drinking purposes for the men, must be free from sewage contaminations and must not contain any poisons (chemical, vegetable, or animal) which might prove harmful. The importance of abundant pure drinking water cannot be too strongly emphasized. An abundant supply must be at hand or immediately available at all times. All possible desirable sources of drinking water must be carefully investigated and examined, and the supplies well guarded and none allowed to be used for other than drinking purposes, until that one all-important need is liberally supplied and future requirements assured. A soldier can march in dirty clothing, person filthy and stomach empty. A thirst crazed man is not in his right mind and if he is for a time inadequately supplied with wholesome drinking water he soon manifests various physical defections and falls a more ready victim to disease.

Streams, large and small, lakes, ponds, wells and springs, are the main sources of drinking water. As a rule, deep wells and deep source springs, furnish the best drinking water, and shallow pools and small streams the poorest, considered from the standpoint of possible harmful contamination. Lakes and larger streams assure an ample supply and the quality may be fair or even very good. Mountain streams fed by melting glaciers and snow, furnish good water.

Four methods are employed in the examination of water, the organoleptic, the microscopical, the bacteriological, and the chemical. Each method has its special advantages and merits and all four are essential.

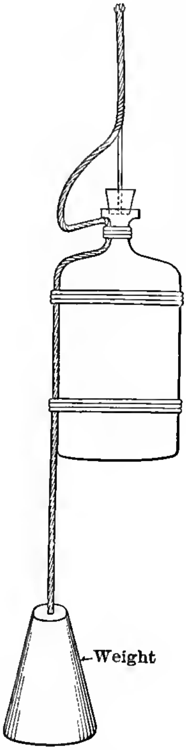

FIG. 27.

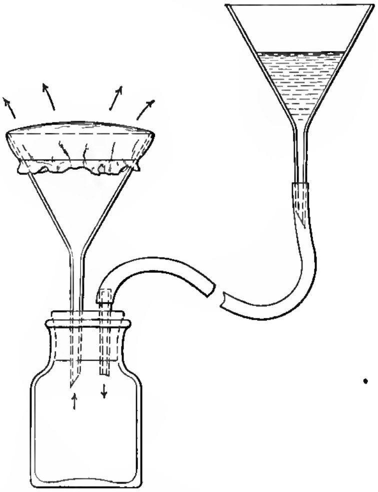

FIG. 28.

FIG. 27.—Arrangement for taking a water sample by means of the Steuer rig. The stopper is drawn when the bottle has reached the desired depth. The attached weight carries the bottle down. This outfit will be found useful in the examination of large bodies of water (lakes, ponds).—(*From Whipple.*)

FIG. 28.—Apparatus for concentrating micro-organisms. (*Whipple.*)

As to the organoleptic tests, water may be wholly colorless or clear; it may be turbid due to fine sand or silt and clay or dirt; it may be yellowish turbid due to fine clay; it may be a yellowish lemon tinge due to diatoms; or greenish due to Nostoc, Oscillaria and other algæ; it may be brown or flocculent brown, due to algæ and to iron fungi (Leptothrix and soil algæ); or it may be wine colored due to peat; etc. It may be and should be odorless. Rain water (from roofs of houses) may have a smoky (creosote) odor or flavor (drained from shingled roofs of houses). Certain algæ (Nostoc, Oscillaria and others) may give rise to very disagreeable odors. Chemicals (permanganate of potassium, hypochlorites, salt, lime) may impart a peculiar taste and flavor. The containers (wood, leather, canvas, etc.) may transmit special flavors. The odor may be garlicky or otherwise disagreeable due to heavy sewage contamination. Pure water is without taste, though it does produce a pleasing gustatory sensation if cool and well aerated. The water in wells in alkali soils, or near large bodies of salt water (ocean, bay, inland seas), may have a decidedly brackish taste. Alkali seepage may impart a bitter or otherwise disagreeable taste. The water of small mountain streams is usually highly contaminated with decaying vegetable matter and frequently also contains decaying animal matter.

In the comparative sense, the highest contamination of bodies of water prevails at or very near the shore, no matter whether the water is at rest or flowing. The least contamination is found at points farthest removed from the water's edge, the bottom and the surface. Gravitation soon carries bacteria to the bottom, while some algæ tend to accumulate near or at the surface. In the case of flowing water, the gradual retardation of the rate of flow toward the shore, causes an accumulation of deposits along the outermost edge of the stream. The intake end of the waterpipe of the pumping station should be as near to the center of the water supply as possible.

The following is a tabulation of the more important contaminations found in water supplies.

I. Derived from soils indicating surface waters and surface seepage.
  1. Vegetable.
    (*a*) Protococcus group.
    (*b*) Desmids.
    (*c*) Diatoms.
    (*d*) Nostoc.
    (*e*) Oscillaria.
    (*f*) Yeasts.
    (*g*) Molds and their spores.
    (*h*) Spores of ferns, club mosses and of other cryptogams.
    (*i*) Pollen grains.
    (*j*) Decayed vegetable tissues.
  2. Animal.
    (*a*) Amebæ.
    (*b*) Paramecia. Flagellata, Spongilla, etc.
    (*c*) Ovæ of Nematodes.
    (*d*) Hair of animals.
    (*e*) Insect fragments.
    (*f*) Animal excreta.

II. Sewage Indicators.
  1. Kitchen refuse—Vegetable.

    - (a) Starches—Cereal, potato, bean, etc.
    - (b) Spice elements.
    - (c) Vegetable tissues derived from fruits, roots, tubers. bulbs, etc., used as food.
  - 2. Kitchen refuse—Animal.
    - (a) Blood corpuscles.
    - (b) Oil and fat globules.
    - (c) Muscle elements.
    - (d) Fibrous tissue elements.
    - (e) Ova of intestinal parasites.
  - 3. Bacteria.
    - (a) Coccus forms, abundant.
    - (b) Diplobacilli, usually abundant.
    - (c) *Streptococcus fecalis.* A positive sewage indicator.
    - (d) A positive presumptive colon bacillus test.
  - 4. Other organisms.
    - (a) Yeasts and mold may be present.
    - (b) Spores of molds and ova of intestinal parasites may be present
    - (c) Motile protozoa.

III. Mineral and inorganic.
  - 1. Oil or resinoid matter derived from vegetable decay (pines).
  - 2. Dirt and clay particles.
  - 3. Sand particles. Coarse and fine. Colorless and colored.
  - 4. Mineral particles and particles of mineral compounds. Colorless and with color. Iron compounds.
  - 5. Diatomaceous earth. Kaolin. Etc.

IV. Amorphous organic particles. These are present in direct proportion to organic contamination.

The analyst should note the following regarding possible available sources of water supply.

1. The character of the underlying geologic formation.

2. The surrounding vegetation and the animals that dwell in the vicinity.

3. The human habitations near the supply.

4. The source of the water.

5. The available amount of the supply. Cubic contents, or volume of flow per hour.

6. All possible sources of contamination and the nature of the contamination.

Among the things which must receive careful consideration in the investigation of larger bodies of water supplies intended for drinking and cooking purposes, are:

1. Does it contain garbage, manure or other refuse? Has it ever been used for dumping purposes? Are the shore lines littered or clean?

2. Does it contain the bodies of dead or decayed animals?

3. Does sewage empty into it at any point?

4. Does it receive surface seepage at the time? What time has elapsed since surface seepage into it has ceased?

5. Is it fed from springs, from streams, or both?

A microscopical examination should be made of the shore and bottom mud and ooze at the points of most likely contamination and a charted record made of the microscopic flora and fauna of the entire shore. If the body of water is small and is highly contaminated by cattle, horses, or hogs, it must be abandoned for drinking purposes, or the animals excluded and the water first purified by the use of some coagulant, by filtration and by boiling. If the body of water is large and the shore is contaminated by animals, the water must be taken from a middle point and either boiled or treated with hypochlorites, or other chemicals. Samples should be taken by means of suitable sampling bottles and some of the water thus collected should be centrifuged and the sediment examined microscopically and the findings recorded.

After the completion of the topographical survey, the organoleptic tests, and the microscopical examination, the analyst is then in position to make his definite recommendations as to what is to be done regarding the water in question. His recommendations will be along the following lines.

1. Unfit for drinking purposes and impossible or impracticable to render it potable.

2. Suitable for drinking purposes in the raw state. Safe. No treatment required.

3. Suitable for drinking purposes, after filtering through sand filter.

4. Suitable for drinking purposes, after coagulating and filtering. Sand-alum filtration. Sedimentation and filtration.

5. Suitable for drinking purposes after adding calcium hypochlorite. Hypochlorous acid sterilization of suspicious water supplies.

Additional methods for purifying water supplies are:

1. The use of Pasteur-Chamberland pressure filters. These are impracticable for army purposes. May be applicable in hospitals (too slow for army use).

2. Use of gravity porous clay filters and coolers. Often quite satisfactory in army hospital. Too slow for army use.

3. Distilling the water. Rather impracticable for army use. Used on ships.

4. Boiling the water for 30 minutes. Very satisfactory for rendering contaminated waters entirely safe for drinking purposes. Not always practicable for army purposes.

5. *Ultra-violet Rays.*—The high voltage ultra-violet ray mercury lamp has been used quite successfully by the French army in the sterilization of drinking water. The lamps are of quartz which permits the more effective passage of the ultra-violet rays, and are placed directly into the water and are said to have a radius of action of one foot, and sterilization is said to be complete in one minute, without resulting in any appreciable physical changes in the water. The rays are not effective in heavily polluted waters nor in water which is not clear. Heavily polluted waters may first be clarified and partially purified by precipitation (the alumn method, 5 grains of alum + 5 grains of sodium carbonate per gallon) and filtration (through sand, charcoal, cotton, cloth, etc., Darnell filter).

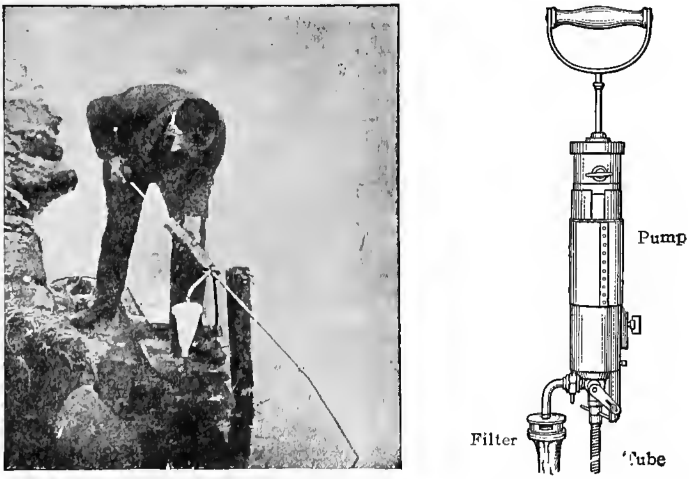

FIG. 29.—Plankton pump. Improvisations may be made on the spot.—(*From Whipple after Wilhelmji.*)

6. *Centrifugal Purification.*—The high speed centrifuge has recently come into extensive use for the purpose of clarifying and purifying liquid and semiliquid substances of various kinds, as sera, gelatinous solutions, emulsions, plant juices, syrups, oils, paints, varnishes, pharmaceuticals, beers, wines, etc. High speed turbine driven machines are now upon the market making from 24,000 to 40,000 revolutions per minute (the Sharples centrifuge). The Sharples machine is of the continuous feed type which may be operated by hand (25,000 revolutions) or by either steam or compressed air (40,000 revolutions). This machine will render water absolutely clear, no matter how heavily polluted, and it is said to remove most of the bacteria. In case of water which is suspected of containing

disease germs (typhoid, cholera, etc.), the centrifuging must be followed by chemical or ultra-violet ray sterilization. This machine will also prove useful for other purposes at the hospital base laboratory. However, the capacity of the Sharples centrifuge is insufficient for army use. If necessity requires, highly polluted waters may be partially purified by precipitation and filtration (sand filter with well formed Schleimdecke) before adding the chemical sterilizers or using the quartz lamp above suggested. The Schleimdecke should be artificially deposited by means of a coagulant as alum.

The analyst will find details for the field application of the sand-alum filtration and the use of calcium hypochlorite in Field Hygiene by Ford and in Sanitation for Medical Officers by Vedder and in other works on army sanitation. The work by Dr. Valary Havard is quite complete and contains numerous valuable suggestions.

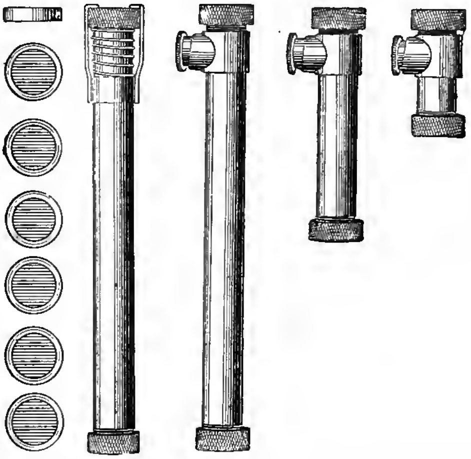

FIG. 30.—U. S. Geological Survey apparatus for measuring the color of water. The water is placed in the metallic tubes having glass ends and the color is compared with a second tube containing distilled water and with one end covered with one or more of the glass discs. The army microanalyst will rarely have occasion to use this apparatus. (*Whipple.*)

The food analyst should be thoroughly familiar with the subject of water purification and should assist the sanitary officers in their work. Sterilization of drinking water by means of chemicals has been very carefully worked out by the armies in Europe. The following chemicals have been used.

1. Chlorinated lime (chloride of lime) with 35 per cent. of available chlorine gas. Action depends upon the hypochlorous acid formed. Amount used ranges from 1 : 1,000,000 to 1 : 25,000.

A chlorinated lime containing 75 per cent. available gas is on the market and is preferable to the weaker lime.

2. Sodium hypochlorite is more efficient and also more expensive. Use about the same amount as of chlorinated lime.

3. Sodium bisulphate in tablets, 30 grains to the quart of water, shake, and let stand for 20 minutes. Excellent for small quantities, as for cavalry men, and for men on the march.

4. Potassium permanganate, 1 grain to the quart, or enough to produce a pinkish coloration. Particularly efficacious against *Bacillus choleræ.*

5. Calcium permanganate is used in Germany to purify water in the canteens (1 grain to the quart). The precipitate which forms must be filtered through a plug of cotton or a filter paper cap.

6. Iodine liberated from the mixing of iodide and iodate, in the canteen, has been used by the French army. The salts are put up in red, white, and blue tablets, ready for immediate use.

7. Halazone (p-sulphon dichloramino benzoic acid) in 1:300,000, is very efficient against typhoid and cholera contaminations. This is cheap and effective. It comes in tablets ready for use (Parke, Davis & Co.).

The caution to be observed in the use of chemical water sterilizers is to mix them thoroughly into the water and allow them sufficient time to act, at least 20 minutes. The amounts used should be adjusted to the degree of contamination which is ascertained by titration (Vedder).

Titrating to Determine the Amount of Chlorine Required.—The following method is adapted from the work by Vedder.

1. Into a rinsed ordnance cup (1 pint or about 500 cc. capacity) break one tube of calcium hypochlorite and mix thoroughly with a few drops of water. Fill the cup with water to within one inch of the top (500 cc.) and mix well by pouring back and forth by means of a second cup. This solution contains 0.3 gram of available chlorine.

2. Rinse four ordnance cups with the water to be sterilized and fill all four cups with water to be tested. To first cup add 0.2 cc. of the test solution in cup mentioned in (1). To second cup add 0.4 cc., to third 0.6 cc. and to the fourth cup 0.8 cc. Mix well by pouring back and forth. Let stand for thirty minutes.

3. Into a clean cup crumble a tablet of potassium iodide (or use a few crystals of the iodide salt), add a little starch solution (made by boiling a little corn starch). Pour into this cup the water to which was added 0.8 cc. of the chlorite. If a blue color appears it is an

indication that not all of the chlorine has been used up in that mixture.

4. The cup which contains the smallest amount of the chlorite which will give a blue color, contains the percentage of chlorine required to sterilize the water to be used.

RELATIVE HUMIDITY TABLE

(Fahrenheit Degrees, Barometer at 30″ of Mercury)

Depression of the wet bulb Thermometer
$(t—t')$

Air temp. (t)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
30°	89	78	67	56	46	35	20	16	6																
35°	91	81	72	63	54	45	36	27	19	10	2														
40°	92	83	75	68	60	52	45	37	29	22	15	7	0												
45°	93	86	78	71	64	57	51	44	38	31	25	18	12	6											
50°	93	87	80	74	67	61	55	49	43	38	32	27	21	16	10	5	0								
55°	94	87	82	76	70	65	59	54	49	43	38	33	28	23	19	14	9	5	0						
60°	94	89	83	78	73	68	63	58	53	48	43	39	34	30	26	21	17	13	9	5	1				
65°	95	90	85	80	75	70	66	61	56	52	48	44	39	35	31	27	24	20	16	12	9	5	2		
70°	95	90	86	81	77	72	68	64	59	55	51	48	44	40	36	33	29	25	22	19	15	12	9	6	3
75°	96	91	86	82	78	74	70	66	62	58	54	51	47	44	40	37	34	30	27	24	21	18	15	12	9
80°	96	91	87	83	79	75	72	68	64	61	57	54	50	47	44	41	38	35	32	29	26	23	20	18	15
90°	96	93	89	85	81	78	74	71	68	65	61	58	55	52	49	47	44	41	39	36	34	31	29	26	24
100°	96	93	89	86	83	80	77	73	70	68	65	62	59	56	54	51	49	46	44	41	39	37	35	33	30

5. *Example.*—Let us suppose that the cup to which was added the 0.4 cc. hypochlorite solution represents the smallest amount just producing a blue coloration, hence enough to sterilize one pint. To sterilize 36 gallons (288 pints, the amount in one Lyster water bag[1]) would require 115 cc. of the test solution in cup (1). The pint of hypochlorite prepared would therefore suffice to sterilize a little over four bags of water. In practice it is customary to use double the amount indicated by the reaction.

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[1] The Lyster water bag is rather unsatisfactory in hot climates. It was not liked by the men on the Mexican frontier.

It must be borne in mind that the filtering material, no matter what the kind, soon becomes clogged with accumulated sediment and rapidly developing algæ and fungi. Therefore the filtering material must be frequently renewed, in some cases, every day and in no case should the interval be more then five days. The analyst should make an examination of the accumulated scum, as this will convey valuable information as to the impurities in the water and the efficiency of the filter. The filter, if not properly attended to, may itself become a source of dangerous infection. Crenothrix forms are very apt to develop in sand filters, especially if there is a deficiency in oxygen supply.

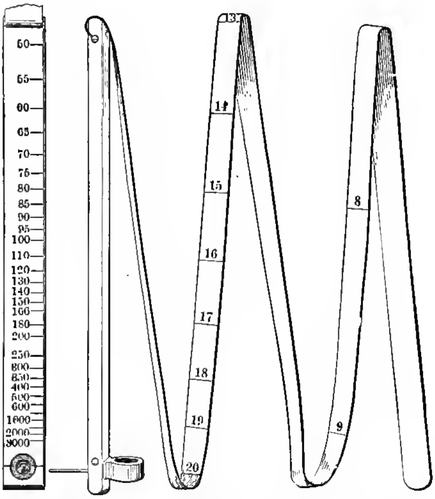

FIG. 31.—The U. S. Geological Survey turbidity rod. The rod is let vertically down into the water as far as the wire at the lower end can be seen and then read the level of the surface of the water on the graduated scale, which will indicate the turbidity. Very naturally it makes a great difference whether the day is cloudy or not, when the observation is made. The observer must also know what interpretation should be placed upon the results of the observations.—(*Whipple.*)

Water supplies (ponds, small lakes) with abundant filamentous algæ may be treated with copper sulphate (1 : 1,000,000) before filtration. This method met with much favor a few years ago, but has been quite abandoned and forgotten recently. The copper sulphate can be placed in a gunny sack, fastened to a boat, and distributed by rowing the boat about until all of the chemical is dissolved. One part in 4,000,000 has given good results, as far as freeing the water of filamentous algæ and also protozoa, is concerned. After filtration no copper can be found in the water. The filtering material must, of course, be renewed occasionally.

Sedgwick and Rafter have devised a method for making a microscopical examination of water. Desirable quantities of water are run through a graduated cylinder, having a sand plug at the lower open end. In place of this cylinder an ordinary glass or tin funnel may be used. Place a perforated stopper (cork or rubber) at lower end, carrying bent outflow tube. On top of opening in the stopper, place a bit of cotton or cheesecloth, followed by ignited quartz sand (sands, Nos. 60, 120, 140, as may be desired). On top of the sand place another bit of cotton or cheesecloth. Pour through the desired volume of water (250 cc., 500 cc., 1000 cc., etc.), and then mix the sand (with the cotton and cloth) in 5 or 10 cc. of distilled or pure water and examine microscopically, making the desired counts.

Sources of Water Pollution.—Various substances are used to detect the sources of water pollution, as salt, kerosene, carbolic acid, saprol, naphtha, fluorescin, cultures of *Bacillus prodigiosus*, etc. Fluorescin (a dye) is perhaps the most satisfactory, when used with the fluoroscope (a glass tube three to four feet long by one inch in diameter, closed at one end with a rubber stopper). 1–2,000,000,000 of the test substance can be detected. Salts of lithium may also be used, as the minutest quantities can be detected by means of the spectroscope.

The test agent (in solution) is poured on the ground or in suspicious places (as sewers, cesspools, privy, etc.), and its reappearance in the water looked for. Care must be observed in making such tests in order to avoid confusing sources of harmless and of harmful contaminations.

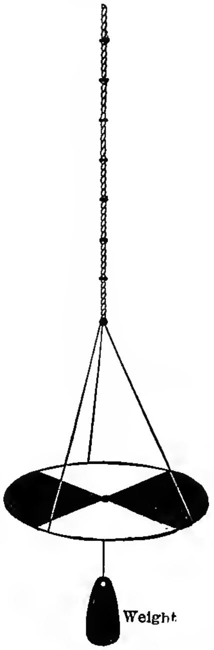

FIG. 32.—Disk for comparing the transparencies of waters. This is used under an umbrella or other suitable sunshade, and with a water telescope.—(*Whipple.*)

The consecutive steps in the purification of highly contaminated water supplies, especially streams large as well as small, may be summarized as follows. *First,* screening or straining for the purpose of removing very coarse matter, such as straw, leaves, sticks, algæ, etc. These screens are usually made of steel wire and must be of the size and strength suitable to the force of flow and the volume of water to be treated; and must be in duplicate, so that one operates while the other is being cleaned. *Second,* passing the water through scrubbing or roughing filters consisting of very porous material through which the water passes very rapidly, as sponge, lava stone, coke, cotton, canvas, etc. This protects the sand filter against too rapid clogging. *Third*, precipitation and sand filtration as already explained; and, *Fourth* and lastly, sterilization (boiling, chemical treatment, ultra violet ray treatment, etc.).

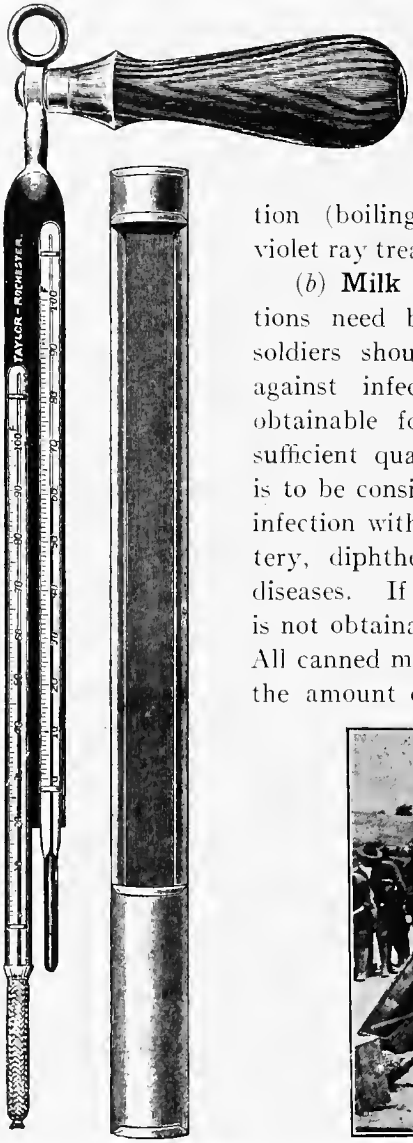

FIG. 33.

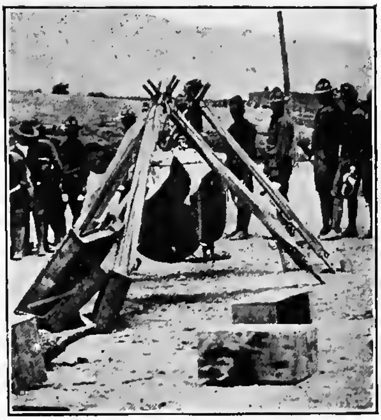

FIG. 34.

FIG. 33.—The sling psychrometer for determining atmospheric humidity. This consists of a wet and dry thermometer. The atmospheric moisture is ascertained from the difference in the temperature of the two thermometers, read off from a comparative humidity table. This device is of considerable practical value in estimating the loss of water supplies through evaporation.—(*Gatewood.*)

FIG. 34.—The Lyster water bag supported by stacked litters.—(*Ford.*)

(*b*) **Milk Analysis.**—Only a few suggestions need be given. All raw milk for soldiers should be pasteurized[1] to guard against infection. Certified milk is not obtainable for army use, at least not in sufficient quantity, and all other raw milk is to be considered suspicious as to possible infection with typhoid, tuberculosis, dysentery, diphtheria, scarlet fever, and other diseases. If recently pasteurized raw milk is not obtainable, canned milk is to be used. All canned milks should be examined as to the amount of bacterial contamination and for the amount of butter fat present. All raw milks should be similarly examined, and all milks (raw and canned) should be rejected if bacteria are excessive. Colostrum can be readily detected microscopically by the large and agglutinated fat globules and the abundant ameboid body cells. Milk containing 3.5 per cent. butter

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[1] Pasteurizing does not always kill all of the colon bacilli.

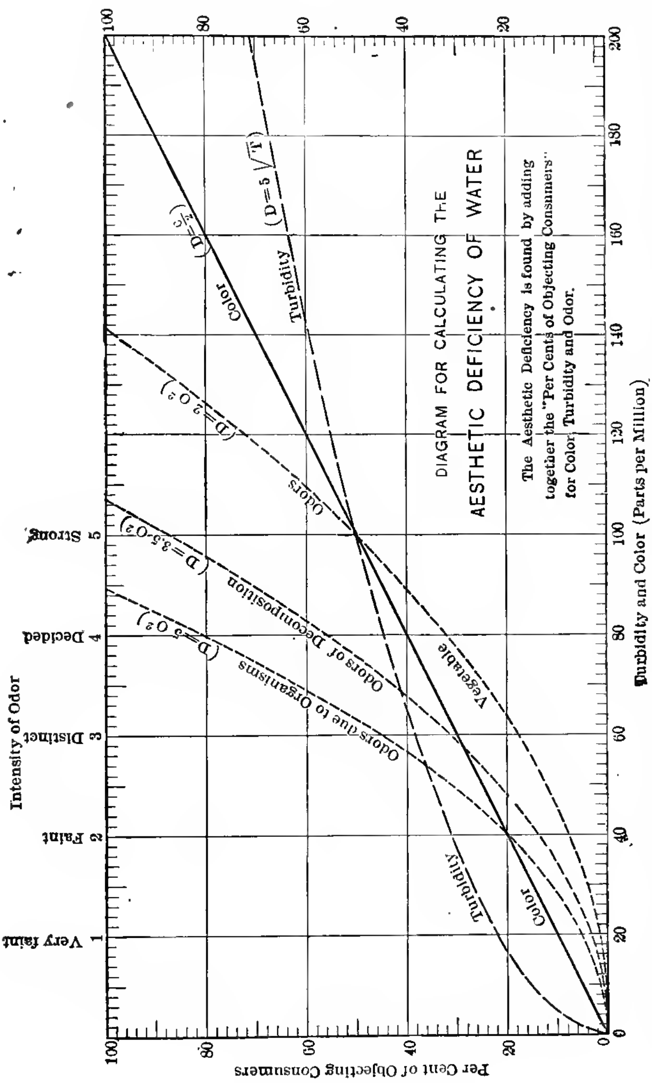

FIG. 35.—Chart of water aesthetics. The abscissas represent turbidity, color and odor, as given in the usual water analyses. The ordinates represent the per cent. of objecting consumers, that is the proportion of water drinkers who will ordinarily choose, *not* to drink the water because of the quality indicated by the curve.—(*Whipple.*)

fat should show at least 2,000,000,000 fat globules per cc., as determined by the hemacytometer. For making the count, a suitable dilution (1 : 100 to 1 : 200) in warm water must be made. The degree of dilution will depend upon the percentage of butter fat present. A dilution of 1 : 100 will be satisfactory for ordinary milk, having 3.5 to 4 per cent. butter fat. Let us suppose that the average of twenty counts show five oil globules in the 1/4000 cmm. areas of the hemacytometer, then the total number per cc. would be 2,000,000,000 (5 × 4000 × 100 × 1000). 578,100,000 fat globules corresponds to 1 per cent. of butter fat. In employing this method for determining the percentage of butter fat in milk, the following modifying conditions and influences must be kept in mind.

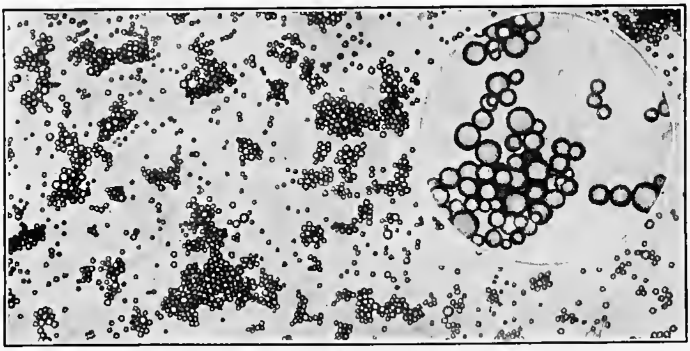

FIG. 36.—Milk fat globules. Larger field as they appear under the low power of the compound microscope (× 80), globules in the corner circle as they appear under the high power (× 500).—(*Hunter, after S. M. Babcock.*)

1. Pasteurizing and boiling the milk causes the fat globules to agglutinate more or less. Two, three, and four globules may be more or less completely fused. As a rule, however, the individual globules composing the aggregates are still recognizable.

2. In homogenized canned plain and evaporated milk, the fat globules are more or less broken up. The globules are therefore smaller but more numerous, than they are in ordinary raw milk. Approximated corrections can be made for this difference in size and in number.

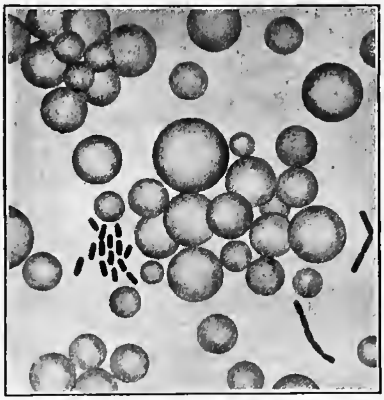

FIG. 37.—Milk fat globules very highly magnified (× 1000). A group of lactic acid bacteria at the left.—(*Hunter.*)

3. In colostrum, the fat globules are much larger than they are in ordinary fresh milk, and many are agglutinated. If the milk shows some unusually large fat globules, with the rather characteristic body cells of colostrum, it is fairly conclusive evidence that the milk

from recently parturient animals was added. Milk is not to be used for human consumption until three days after parturition. In some countries colostrum is cooked and eaten.

(*c*) **Beverages.**—Including the beverages proper, ready for immediate use, and certain of the ingredients used in making beverages. The all important beverage, water, has already been mentioned.

Beverages may be grouped as follows:

1. Primarily thirst allaying and essential to life. Water is the only beverage belonging to this group. Milk is essential to the infant, but is not absolutely essential to the normal well-being of the adult.

2. Acid plant juices added to water. Lime juice, lemon juice, orange juice, grape früit juice, and the aromatic acid juices of other fruits, are frequently added to the drinking water for their pleasing cooling effect and also for the purpose of destroying certain pathogenic bacteria which may be present. The typhoid, paratyphoid, cholera, and dysentery bacilli, are quite readily killed in acid media. Exposure to 1.5 to 2 per cent. citric acid, for from 10 to 20 minutes kills them. Suspicious water supplies may be rendered reasonably safe by adding the juice of one-half lemon, or the equivalent of other acid fruits, to the tumblerful, stirring and allowing to stand for 15 to 25 minutes. The juice from one lemon may be squeezed into the canteen, and the canteen then filled with water. Unfortunately these very desirable acid fruits are only occasionally at hand and such as are available are usually reserved for hospital use.

The acidulated water may be sweetened with sugar, thus giving the drink a corresponding heat and energy producing property. The aromatic oils in the rind of the lemon, lime, orange, and in other fruits, have slightly stimulating, and also antiseptic properties. Lemon oil, for example, is ten times more germicidal than ether or alcohol.

3. Unfermented fruit juices. Such as grape juice, fresh or sweet cider, and pear juice. These are relished for their pleasing flavor or aroma, and acidulous sweet taste. They are cooling and slightly nourishing. Orange juice is reputed to be nourishing as well as rich in vitamines, especially efficacious in warding off scurvy. Fresh fruit juices decompose readily (yeasts, molds, and bacteria) unless properly pasteurized and bottled.

4. Fermented fruit juices. This includes wines, cider, and perry (fermented pear juice). If properly fermented, filtered, pasteurized and bottled, they keep fairly well. They have a limited use, as prescribed by physicians, largely in hospital practice. These bever-

ages frequently spoil, through the entrance of wild yeasts, molds and bacteria. Preservatives are frequently added, especially salicylic acid.

5. Alcoholic beverages generally. Brandy, whisky, saké, gin, cordials, etc., have limited use in hospital practice only.

6. Beers, porter, and ale are wholly non-essential and find only occasional use in hospital practice. Their extensive use interferes with digestion, and they are bad for the kidneys and reduce physical endurance.

7. Non-alcoholic stimulating beverages. This includes tea, coffee, cocoa, beef tea, and meat broths. These have already been referred to or will be referred to later. Tea and coffee have no food value. Cocoa, beef broth, and beef tea, have some food value, especially cocoa and chocolate.

Spoilage of drinks of all kinds may be caused by bacteria, yeasts, and mold, and such spoilage is readily detected by means of the compound microscope. There are many other beverages, such as ginger ale, soda water, pop, lemonade, and the entire array of so-called soft or soda fountain drinks. Also egg-nog, egg-beer, spiced beers, so-called medicated whiskies and brandies, cordials, etc., etc., none of which are of any special interest to the army, excepting that the men should be warned against the indulgence in such drinks while on leave.

(*d*) **Canned Foods.**—The examination of canned foods is of the greatest importance. Not a single can should be used which has not been carefully inspected or examined. The following is a brief outline of what actions are to be taken regarding this class of food.

1. Reject, without further examination, all swells and all distinct springers.

2. Reject, without further examination, all leaks.

3. Reject, without further examination, all food substances taken from cans in which the tin on the inside of the cans is distinctly corroded, with or without darkening or blackening of the tin.

4. Reject, without further examination, all "flat sours." Flat souring is evident on opening the can and examining the contents organoleptically. The microscope may be used for verifying the existence of decomposition changes.

5. Reject all canned foods which give off a putrid or otherwise disagreeable odor. Dickson and others who have made a careful study of botulism traceable to both animal and vegetable foods, lay special stress upon a "cheesy" or butyric acid odor as an indicator of the presence of the *Bacillus botulinus*. All canned foods, especially those packed by the cold process, and all pastes in cans and

in barrels, showing spore bearing bacilli and emitting a cheesy or faintly butyric acid odor, should be rejected without further examination. It is a popular belief among Italian tomato paste makers, that the custom of packing the paste in barrels, alternating the paste with layers of salt, will keep the article indefinitely. This is a mistake as animal feeding tests have shown that such pastes are occasionally highly toxic, due to the toxin formed by the sausage bacillus. It is even dangerous and fatal to taste of raw or uncooked foods which are infected by the botulism organism. Thoroughly cooking (for one hour or longer) will destroy the toxin as well as the bacillus and the spores, but it is not advisable to take a chance with such foods, even when thoroughly cooked.

6. All canned food substances which are discolored, mottled, or otherwise off color, meats especially, should, as a rule, be rejected. Other organoleptic tests should be made, also a careful microscopical examination, if thought necessary. Discolored meats may have been treated chemically to mask decomposition changes.

7. All "do over" cans, all "flippers," all cans with friction caps, all containers showing poor or imperfect sealing, should be looked upon with suspicion. The contents may be all right and again they may not be. These should be carefully examined.

8. All canned food substances (usually vegetables) showing the following microscopical findings should be rejected without further examination.

(*a*) 1,000,000 or more bacterial endospores per cc. or per gram.

(*b*) 100,000 chains, or more, per cc. of *Streptococcus fecalis*, or other streptos.

(*c*) Mold in 25 per cent., or more, of the fields of view (either low or high power) of an ordinary slide mount (or with the Schneider or Howard mold counter). Any field showing a distinct hyphal fragment or a distinct hyphal cluster, is to be counted positive. Exceptions *may* be made of the class of food substances used in small quantities only, as for example tomato paste (not to exceed two ounces at one meal). However, no food substance should be used for human consumption, no matter how small the quantity, in which 50 or more per cent. of the fields show mold.

9. All canned food substances not referred to under (1) to (8) inclusive, which appear clean and wholesome to the naked eye and which have a pleasant and normal odor and good taste, may be passed as suitable for human consumption, without further examination. Should the faintest doubt exist in the mind of the analyst, he should examine the contents of two or three cans microscopically for con-

taminations, condition of tissues, etc. If the contamination is found to be negligible, the food is to be pronounced satisfactory.

If the analyst is satisfied that the canned food in question is good and wholesome, he should call the attention of the company cook and the mess sergeant to the appearance of the article, requesting them to compare it with the contents of other cans of the same kind of food, as the cans are opened.

10. Foods in large cans (5 gallons or more), in kegs and in barrels, are very apt to be of poorer grade or quality, than the same kind of food in smaller containers, and they should therefore receive the special attention of the analyst.

11. All salvaged (wrecks, fire, water) canned foods should be carefully examined before rendering a decision regarding them. Likewise all food substances (canned and others) taken from the enemy, as has already been suggested.

One of the most important and dangerous decompositions in canned fish (most common in sardine and other small fish) is "pink rot," most distinctly noticeable in the muscular tissue along the spinal column. The meat assumes a pronounced pinkish red coloration and has a marked characteristic pungent, acrid, taste (most distinctly noticeable on tip of tongue), without any distinctive odor. In fact, even very marked pink rot, permeating much of the adjacent tissues, results in only slight change in odor. The infection almost invariably takes place prior to cleaning, gutting, and processing. Muscular tissue affected with pink rot will show billions of bacteria (probably belonging to the Gærtner group) per gram and all fish thus decomposed must be rejected.

While the trouble quite generally starts in the immediate vicinity of the spinal column, it may spread and finally permeate the entire fish. It may start peripherally under broken skin areas, or at the edges of cuts made by the cleaning and trimming knife. The pink coloration fades on exposure to the atmosphere.

The predominating type of microbe in pink rot appears to belong to the Gærtner group, but in some cases other associates are found, as coccus forms and large bacilli resembling the hay bacillus. The infection though long known to the practical canner, requires further careful study on the part of bacteriologists.

Canned fish (sardine, herring) showing broken skins (abraded skins) should generally be rejected as decomposition exists in proportion to the skin area denuded. The remaining skin usually shows scales very loosely attached and the superficial tissues more or less smeary. Skin rot contamination is quite generally traceable to dirty cleaning and dressing tables. Gutting is very frequently badly done. In many fish the entrails are either not removed at all or only partially removed.

The micro-analyst must be familiar with the modern methods of canning foods, and should inspect canneries whenever this may seem desirable. There are many hand books on methods, but most of them are written from the viewpoint of the so-called "practical canner," and are quite lacking in the all important scientific facts and data. The following suggestions will prove valuable on making a tour of inspection of canneries.

Cannery Rules

1. Clean minds, clean morals, and clean bodies.
2. Employees must abstain from the use of alcohol and tobacco.
3. Clean hands are absolute essentials. Wash and wipe hands as often as may be required during working hours. Cuts and abrasions of fingers and hands must be properly cared for at once. Those workers with abscesses and sores (streptococcic and staphylococcic), of long standing must not be allowed to handle fruit or fruit products.
4. All laborers should wear clean uniforms while at work in the cannery.
5. Ample lavatory and water closet facilities must be provided. The water closet must not open directly into the operating rooms.
6. Everything in and about the cannery must be clean and kept clean.
7. All food products should be examined by a competent analyst before processing and only good wholesome food should be canned.
8. The entire canning process should be in accord with the best modern methods.
9. All defective cans should be culled at the cannery. "Doing over" (of leaks) should be done at once. No old leaks should ever be done over or used in any way.

Process for Canning Smoked Herring and Other Fish

1. Place the wholesome, clean, smoked fish in a grate and boil in olive oil for five minutes (parboiling).
2. As soon as the fish is cool enough to be handled, pack in the cans.
3. Pour on hot olive oil. It is very important that good oil be used.
4. Cap the cans while hot.

5. Process for one hour and fifteen minutes at a temperature of 240° Fahrenheit.

6. While the cans are still hot, rinse them in a solution of lye order to remove the oil which may be on the outside of the cans.

7. Cool somewhat at air temperature and then in a tub of water. Too sudden cooling must be guarded against as the strain on the seams may result in leaks.

8. Label and pack for shipment.

Sardines may be canned in a similar manner. Herring and sardine not smoked need not be soaked so long in the olive oil. Usually two or three minutes will suffice, but the processing should, if anything, be prolonged, say to one hour and thirty minutes.

It is very important that good wholesome fish be used. Smoked and dried fish is very frequently infested by mold and also by bacteria. Very naturally these micro-organisms are killed by the drying and smoking processes, but the evidence of the decomposition nevertheless exists as may be seen from a microscopical examination. The cultural methods may give wholly negative results. The canning stock should therefore be very carefully examined in order that the finished product may comply with the requirements of the pure food laws, both federal and state.

(*e*) **Flours and Meals.**—These are among the most important of the army food supplies and are made from cereals and from a variety of well-known plants, as buckwheat, corn, peas, beans, lentils, potatoes, yams, sweet potatoes, taro, poi, dasheen, bananas, pumpkins, squash. Even cotton seed cake, flax seed cake, Kaffir corn, millet, and many of the dried vegetable products, may be made into flour.

The flours and meals should be examined as to identity, quality, and freedom from adulterants, for which purposes the organoleptic tests, certain physical tests, and the microscopical examination, are employed.

The analyst must be able to identify, at a glance, any of the commercial starches, flours, and meals, under the compound microscope. This is comparatively easy as the starch granules of the different flours are morphologically different. The polarizer is occasionally of great value in the identification of starches and in detecting admixtures of starches and flours. Some starch granules (of potato, arrowroot, corn, legumes) polarize well, while others (of rye, wheat, barley, ginger) polarize faintly or indistinctly. By means of the polarizer it is possible to detect even very small admixtures of corn starch, potato starch, and arrowroot starch.

The micro-analytical problems, as far as flours and meals are concerned, pertain to.

1. Determining the identity. This is simple indeed, since the microscope will reveal this to the skilled analyst at a glance.

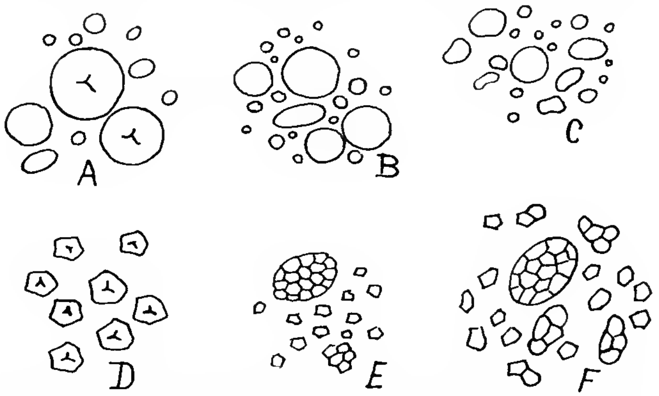

Fig. 38.—Starches. A, rye starch; B, wheat starch; C, barley starch; D, corn starch; E, rice starch; F, oat starch.

2. Detection of admixtures and determining the proportions of such admixtures. This is simple, as a rule. Occasionally difficulties are encountered. It is, for example, not easy to detect admixtures of wheat and barley, or of rice and millet, because of the similarities in the starch granules.

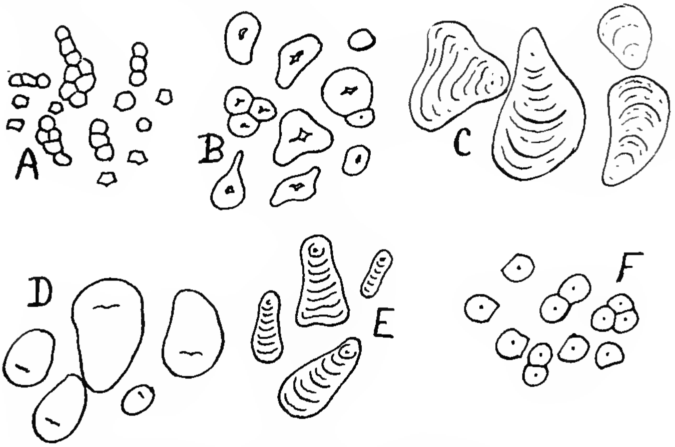

Fig. 39.—Starches. A, buckwheat starch; B, chestnut starch; C, potato starch; D, maranta (Arrowroot) starch; E, yam starch; F, cassava starch.

Quantitative estimates of the proportions of admixtures, as in pancake flours, the flour used in so-called arrowroot biscuits, breakfast foods, flours for bread making under the war regulations, etc., are to be made as follows: Weigh out one gram of the substance (if a flour, starch, or other very fine powder), moisten and thoroughly stir in a small quantity of water and pour into a 100 cc. graduated cylinder, fill up to the 100 cc. mark with a 1.5 per cent. gum arabic solution (or the equivalent of some other gum, or of glucose, or syrup) and shake thoroughly. Mount a droplet of the thoroughly mixed sample on the Levy (or Thoma-Zeiss) counting chamber and make careful counts (10 to 50 of the 1/4000 cmm. areas), of the several components, and compute the values from the table of numerical starch count values. Let us suppose that a given flour shows the following counts; corn starch granules per gram, 226,000,000, and wheat starch granules 665,000,000, then we would find from the table of starch counts that the flour in question was composed of corn meal 25 per

TABLE OF NUMERICAL STARCH COUNTS AND STARCH PERCENTAGES[1]

Name	Starch granules (per gram)	Numerical starch count ratio (corn starch as 1)	Starch percentage
Banana flour	281,150,000	0.115	22
Barley flour	3,624,000,000	1.490	62
Bean flour	206,650,000	0.084	57
Corn starch	2,432 000,000	1.00	100
	1,880,000,000	0.778	
Corn meal	1,305,000,000	0.703	71
	520,000,000	0.213	
Ginger (peeled)	1,919,000,000	0.789	20
Ginger starch	2,314,000,000	0.951	100
Graham flour	309,973,000	0.168	75
Maranta starch	465,000,000	0.190	100
Oatmeal	4,769,000,000	1.960	68
Pea flour	182,325,000	0.075	55
Potato meal	131,650,000	0.054	80
Potato (raw)	50,700,000	0.021	18
Potato starch	147,500,000	0.061	100
Rice flour[2]	1,660,000,000	0.682	79
Rice, ground[3]	3,280,000,000	1.348	79
Rye flour (grain)	2,984,000,000	1.227	78
Sago (Pearl)[4]	80,975,000	0.004	100
Wheat flour (white)[5]	910,000,000	0.375	75
	1,822,000,000	0.749	
	2,400,000,000	0.987	

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[1] From a table prepared by Berger at the author's suggestion.

[2] The aggregates were counted as one.

[3] The aggregates were broken up and the individual granules were counted.

[4] Exact count impossible because of the agglutination of many granules.

[5] There is considerable variation in the number of starch granules in the different wheat flours and also in the ratio of larger (15μ and over) and smaller (less than 15μ) starch granules in one and the same variety of wheat flour.

cent. and wheat flour 75 per cent. In this case the Levy (or other) counting chamber is not necessary, because the proportion of corn starch and of wheat starch (averages of each from a number of fields of an ordinary slide mount or of several slide mounts) will indicate the relative percentages. Let us suppose that the counts of 20 fields shows an average of 13 corn starch granules, the other ingredient being wheat flour with an average of 9 starch granules per field, we may then ascertain the percentage of cornmeal as represented by the corn starch granules, the complement percentage would be wheat flour. In this case the sum of the average of both counts would be 22 starch granules and $^{13}/_{22}$ of the total numerical count would represent corn meal, and $^{9}/_{22}$ would represent wheat flour. By comparing with the table this would prove to be a 50:50 mixture. ($^{13}/_{22}$ of 2,215,000,000 = 1,305,000,000 and $^{9}/_{22}$ of 910,000,000 = 372,273,000, which numbers stand for the starch counts (corn meal and wheat flour) in a 50:50 mixture, as may be seen from the table of starch counts.

The percentage of gluten in wheat flour may be roughly and quickly estimated by the hand method. Mix flour with water into a kneadable dough, weigh the dough, work out the starch thoroughly and weigh the gluten. Wheat flour contains about 30 per cent. of moist gluten. With care practically all of the starch can be worked out without losing any of the gluten.

(*f*) **Meats.**—The following is an outline of the methods applicable to the examination of meats of all kinds.

I. Organoleptic tests.

1. *Appearance.*
   - (*a*) As to color—Red, pink, pale, bluish, yellowish, blood spots, mottled, speckled, dark, discolored, blackened, etc.
   - (*b*) Optical evidence of bladder worms, trichinæ, mold, maggots, mites, ants, etc. (Sight combined with feel.)
2. *Feel or touch.*
   - (*a*) Smeary, slimy, crepitant; evidence of decomposition.
   - (*b*) Tough, friable, soft, spongy, puffy—Age and quality of meat. Decomposition changes.
   - (*c*) Nodules, lumps, caseous spots, etc. Tuberculosis etc.
3. *Odor.*
   - (*a*) Tainted, bad, putrid.
   - (*b*) Musty, moldy, etc.
   - (*c*) Creosote odor, garlic odor, spice odor, etc.
4. *Taste.*
   - (*a*) Salty, pungent, spicy.
   - (*b*) Sour, bitter, bad, etc.

II. Microscopical examination.

1. *Micro-organisms.*
   - (*a*) Bacteria—Upon the exterior and in the interior. Endospores, Spore formers.
   - (*b*) Mucor. Penicillium. Spores and mold hyphæ.
   - (*c*) Yeasts and yeast-like organisms.
   - (*d*) Larvæ of parasites.
   - (*c*) Bladder worms in beef. Trichinæ in pork.
2. *Non-living elements.*
   - (*a*) Food elements, excreta, etc., from intestinal tract, in fish, in carelessly dressed game and domestic birds, etc.
   - (*b*) Cereal, cereal fillers, tragacanth fillers.
   - (*c*) Spices and condiments, as allspice, pepper, cloves, onions, garlic, etc.
   - (*d*) Coloring matter and evidence of added preservatives. (Coloring particles, crystals, etc.)
   - (*e*) Blood corpuscles.

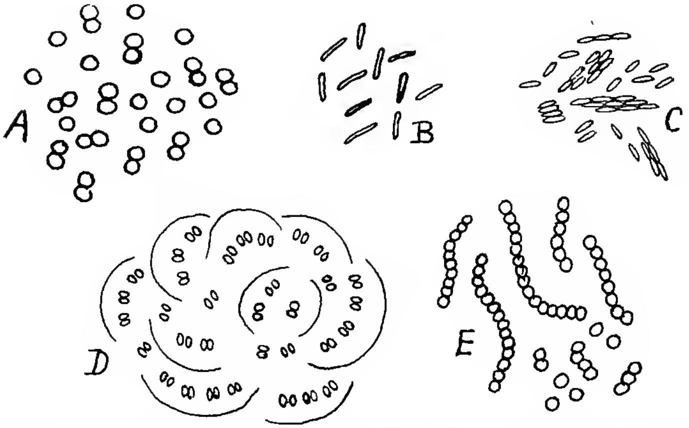

FIG. 40.—Types of bacteria found on smoked meats. A, a diplococcus very common and abundant on smoked meats, on the casings of sausages, on sliced meats, dried meats, etc.; B, a slender bacillus resembling the tubercle bacillus found on dried meats; C, agglutinated bacteria very common on smoked bacon; D, *Diplococcus mesenteroides*, fairly common on old smoked meats; E, Streptococcus form common on meats.

III. Plate cultures. (Lactose-litmus agar, and gelatine media).

1. *Numerical estimation of living bacteria present.*
2. *Gas formers and acid formers.* High temperature (37°C.) and low temperature (20°C.) bacteria. Gelatine liquefiers. Indol reaction.

IV. Tube cultures.

1. *Bacillus coli* test (presumptive).
2. *B. botulinus* (anaerobe).

V. Toxicological tests.

1. *Feeding and inoculation tests.*
   - (*a*) Feeding tests on cats, dogs, chickens, for ptomaines and toxins.
   - (*b*) Inoculation tests on guinea pigs, for tuberculosis.

VI. Determining the source of meats.

1. Beef, pork, mutton. Feel, odor, flavor, taste.
2. Sugar test (for horse meat). Also feel, color, taste.

3. Microscopical identification based on the difference in the structure of the mucular fibers and of the ultimate muscular elements, and the length and form of the fat crystals.

The routine field work will be largely limited to a careful organoleptic testing and the microscopical examination. The casings of sausages which have been stored in damp places are very often smeary to the touch. The microscopical examination will show that the exterior of the casings is coated with large coccus forms. Pickled pigs feet are often smeary to the touch, due to the presence of abundant bacteria and yeast-like organisms. Sausage meats and sausages frequently show abundant bacteria (15,000,000 to 1,000,000,000, and more, per gram). The exterior of meat often shows abundant bacteria. All distinctly tainted meats must be rejected. Meat from old animals is dry, tough and comparatively pale in color, and the fat of old cattle is more or less yellowed. Horse meat is coarser and more highly colored than beef, and has a sweetish taste. Pork and other meats pickled in brine, with saltpeter, have a peculiar pinkish red coloration. If, when the spinal column is lifted from canned fish, a distinct reddish coloration is seen in the meat underneath, this indicates bacterial decomposition (pink rot).

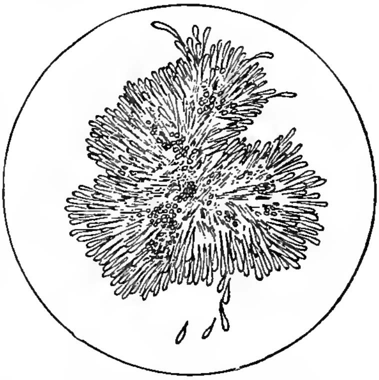

FIG. 41.—Colony of *Actinomyces bovis* from cow.—(*Williams.*)

A factor causing some confusion and difficulty in the microanalysis of canned meats (spoiled before the processing) is the agglutinated appearance of the bacteria (usually of the Gærtner group). The fact that the ultimate elements of the muscle fibers are often set free by various molecular and physico-chemical decomposition changes, and are readily confused with the bacterial elements and aggregates, adds to the difficulty and confusion. For example, the muscle elements of the turtle resemble very closely certain Streptococcus forms, while the ultimate muscle elements of the fish resemble Streptobacillus forms. These difficulties are not so pronounced in the examinations of meats of the higher animals, as beef, pork, veal, etc.

The meat of animals afflicted with lumpy jaw (Actinomycosis) should not be eaten. Meat from slightly tubercular animals might be used in case of necessity, provided it is thoroughly cooked before eating. This also applies to meat from hogs affected with trichinosis.

Horse meat is good, so is that of many other animals now not generally eaten. In the United States the meat of the tuna, of the whale, the porpoise, and the sea cow, has recently been tried out for eating purposes, with rather indifferent results. The tuna meat alone has thus far met with general favor. The abalone (a shellfish) has met with favor, due largely to the efforts of a few enterprising restaurant men.

All fish and all shellfish require careful examination as has already been set forth, whether in the fresh state, or salted, or kippered, dried or canned. Oysters should not be eaten at all unless they are for a certainty from beds free from sewage contamination, and are not soaked.

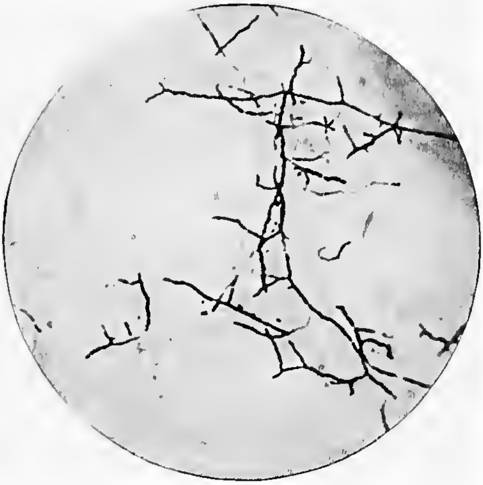

FIG. 42.—*Actinomyces bovis* from broth culture (× 1000).—(*Williams.*)

The first gross decomposition changes in meats (indicated by a putrid odor) develop about the joints, as in beef, pork, mutton, etc., and along the spinal column in the fish group. In poultry the decomposition changes are usually first noticeable in the abdominal region; next, near exposed bone ends, the neck region in particular.

The decomposition of crustaceans is variable. Shrimp often gives off a marked ammonia odor due to bacteria. Shrimps and prawns should not be eaten unless taken fresh and immediately prepared for the mess, and provided also they are free from sewage contaminations.

THE KEEPING POWER OF RAW MEATS

As has already been indicated, the meats from different species of animals vary greatly in the keeping power; that is, in the resistance to the decomposition changes resulting from bacterial invasion. The following tabulation indicates the time which elapses in summer temperature (40° to 100°F.) and winter temperature (40° down to −10°F.), before raw meat from recently killed or slaughtered animals, begins to show more or less pronounced decomposition changes. This time must not be taken too literally. The table merely serves to indicate what has already been stated, namely that shellfish, crustaceans, fish, meats of older and younger animals, etc., differ in keeping qualities. Numerous factors, other than temperature, must be taken into consideration.

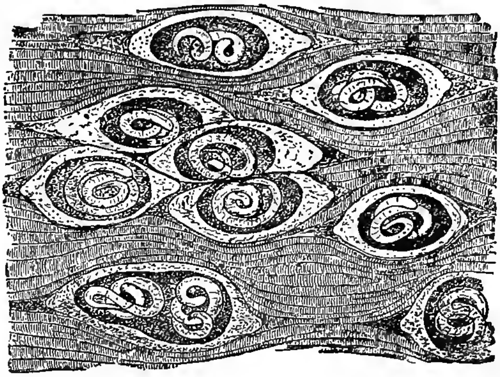

FIG. 43.—Encysted *Trichina spiralis* (*Trichinella spiralis*) in muscle tissue.—(*Stitt, after Ziegler.*)

Kinds of Meat	Days	
	Summer	Winter
Shellfish (Out of shell)	1	2–3
Crustaceans	1	3
Fish	1	3
Sheep	2	3
Calves	2	4
Lambs	2	4
Young pigeons	2	4
Young domestic fowl	2	4
Partridge	2	6–8
Hare	3	6
Cattle	3	6
Hogs	3	6
Capons	3	6
Old roosters	3	6–7
Turkeys and geese	4	8
Deer	4	8–9
Pheasant and black grouse	4	10
Wild boar	6	10
Wood grouse	6	14

Good meat should be red in color (the degree of redness depends upon the species of the animal from which the meat is taken), not purple, or dark red; should not pit under pressure; should not have the faintest disagreeable odor; should be "dry," that is it should moisten the finger only slightly; and there should not be any disagreeable after taste.

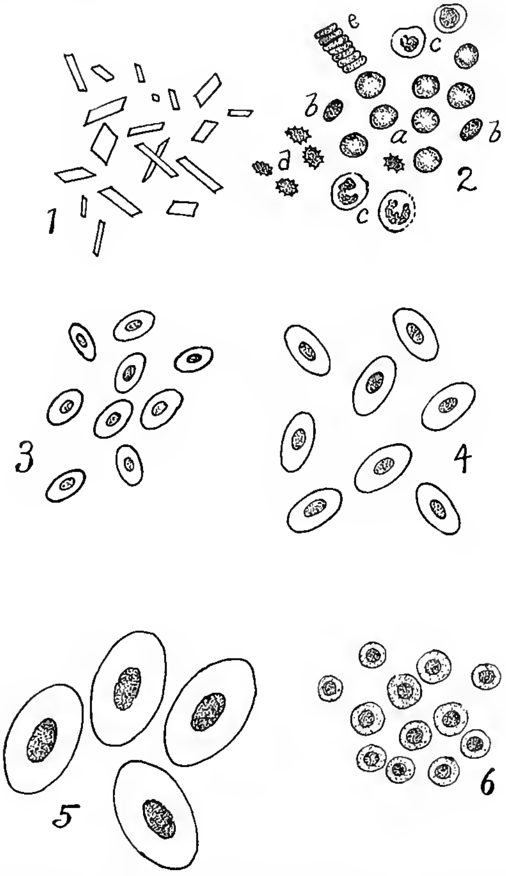

FIG. 44.—Blood elements. 1, hæmin crystals; 2, human blood, *a*, normal red corpuscles; *b*, beginning crenation; *c*, mononuclear and polymorphonuclear leucocytes; *d*, crenated red corpuscles; *e*, agglutinated red corpuscles; 3, fish blood corpuscles; 4, frog corpuscles; 5, proteus corpuscles; 6, nucleated red corpuscles of man (from red marrow).

Meat cooked while in *rigor mortis* is apt to be tough. Very dark meat suggests improper bleeding or suggillation. Domestic fowl or bird game is never improved by cold storage. Tough meat can be softened if the cooking is sufficiently prolonged. It is custom to remove the testicles from a bull as soon as killed so as to prevent the more extensive dissemination of the sex odor throughout the meat.

The somewhat fishy flavor of the meat of wild water fowl is not considered objectionable by most persons. The relish for the socalled "gamey flavor" indicates a perverted taste, as the flavor is due to initial decomposition changes.

The following meats are, in general and as a rule, considered unsuitable for human consumption.

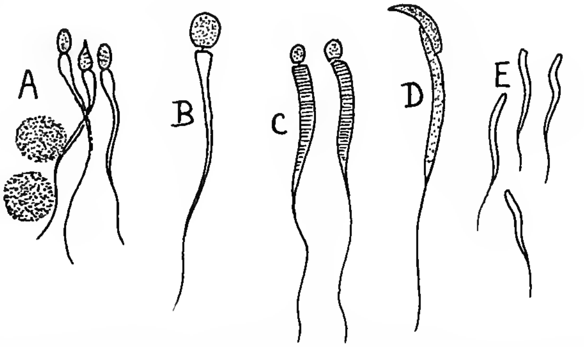

FIG. 45.—Animal spermatozoa. A, human with two companon cells; B, badger; C, bat; D, rat; E, domestic fowl.

1. Meats of animals affected with trichinosis (*Trichinella spiralis*).

2. Meats from bulls, stags and old cows. Especially the meat from bulls castrated late in life. Such meats are edible and possess almost full nourishing values, but they are quite generally rejected.

3. Meats from cattle afflicted with lumpy jaw and abundant tubercular nodules. Slightly tubercular meat may be used provided it is thoroughly cooked before eating.

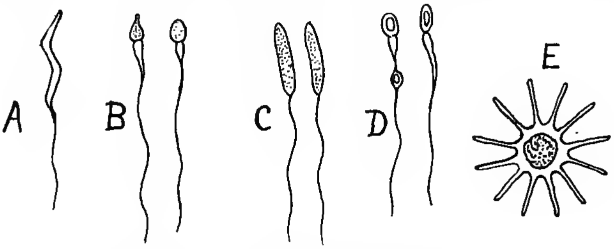

FIG. 46.—Animal spermatozoa. A, finch; B, monkey; C, frog; D, boar; E, crab. Of occasional diagnostic value in the identification of meats.

4. Meat from cow with calf or from cow just after parturition.

5. All meats from animals dead of disease or killed while suffering from disease (especially acute infectious bacterial diseases).

6. Meat from poisoned animals and meat from animals which are themselves poisonous.

7. Meat from overworked or over exercised animals.

8. Measly meat (pork and beef); that is, meat containing the bladder worm stage of the tapeworm.

9. All tainted and putrid meats. All meats (raw) having a sticky, slimy, or crepitant feel, with or without bad odor.

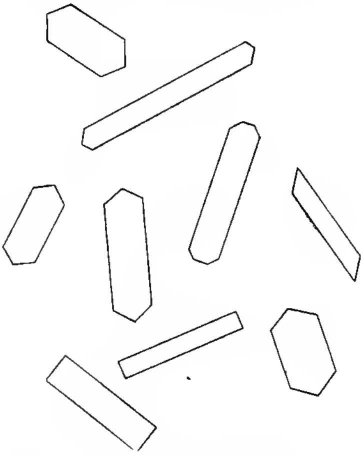

Fig. 47.—Phytosterol crystals.

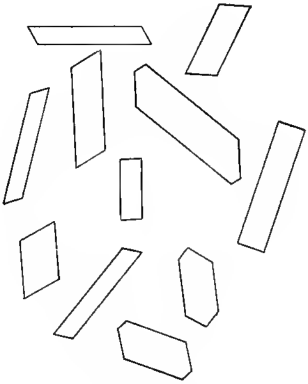

Fig. 48.—Cholesterol crystals.

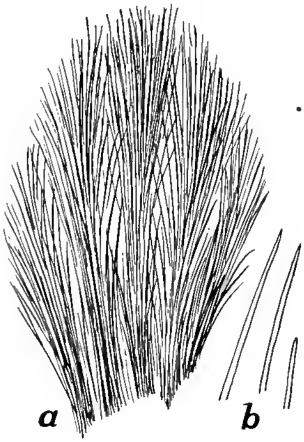

Fig. 49.—Beef fat crystals. *a*, Clusters of crystals as seen under the low power of the compound microscope; *b*, crystals highly magnified.

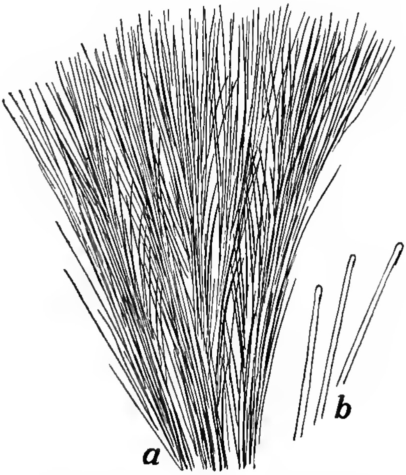

Fig. 50.—Duck fat crystals. *a*, Clusters of crystals as seen under the low power of the compound microscope; *b*, crystals highly magnified.

10. Meats, livers, kidneys, brains, and all tissues and organs which are considered edible, which are decidedly off color or unusually soft, crepitant or otherwise markedly abnormal in appearance, even if the odor and taste appears to be all right. Liver is difficult to digest, though it is said to be rich in vitamines. Many refuse to

eat kidneys. Livers from forcibly fed geese are considered a delicacy in some countries (France, Germany) (Pâté dé foie gras).

The following is a list of the more commonly employed meats.

1. Beef. Veal.
2. Pork.
3. Mutton.
4. Goat.
5. Horse.
6. Poultry, fowl, duck, goose, turkey. (Wild and domestic.)
7. Fish—Anchovy, bass, blue fish, carp, catfish (bull-head), cod, halibut, herring, mackeral, pompano, tuna, mullet, salmon (red and pink), sardines (pilchards), shad, red snapper, sturgeon (caviar), trout, and whitefish.
8. Shellfish—Oyster, clams, mussels, abalone, scallops, snails.
9. Crustaceans—Lobsters, crabs, shrimps.
10. Miscellaneous—Turtles, eels, terrapin, frog's legs, snakes, whale, porpoise, dog, cat, rat, squirrel, badger, racoon, bear, deer, etc., etc.

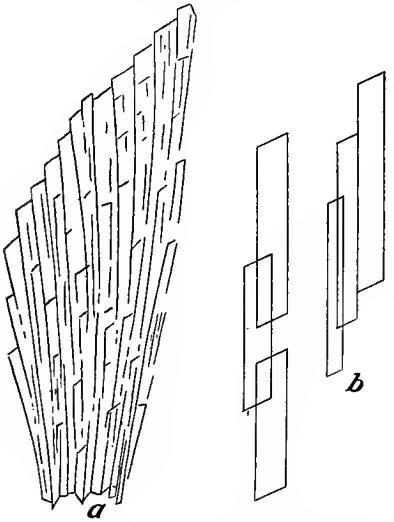

FIG. 51.—Lard crystals. *a*, Clusters of crystals as seen under the low-power of the compound microscope; *b*, crystals highly magnified.

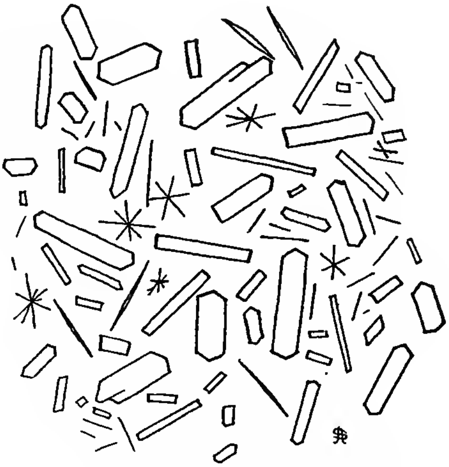

FIG. 52.—Crystals of smoking opium.

The meat of almost all land and flying animals may be eaten, the need being sufficiently great. The strongest repugnance pertains to the meat of carrion feeders, as the buzzard and the jackal. Next, the meat of the birds of prey, then the meat of the carnivora, of the cat family, and the dog family. Dog meat is, however, relished by the American Indians, and cat meat was eaten during the siege of Paris (1870). Some meats are edible but are objected to because of strong flavors. The meat of monkeys is eaten in some tropical countries. The meat of the rattlesnake is said to be edible and to have a delicate flavor. Rats and mice are eaten in some countries. Even many of the insects (locusts and grasshoppers) are eaten. Practically all feathered animals are edible, both wild and domesticated.

The microscopical examination of blood corpuscles is often the means of identifying the meat from which they are derived, as may be seen from the following table of blood corpuscle measurements. It must, however, be borne in mind that blood corpuscles disintegrate quite readily, particularly those of the higher animals. The red corpuscles of lower vertebrates (fish, lizards, frog) and of molluscs (clam, oyster) are quite enduring. They are often found quite intact in canned fish and oysters.

Size of animal bears no relationship to size of corpuscles (compare humming bird and elephant). The corpuscles of the mammalia are circular with the exception of those of the camel which are elliptical like those of the bird group. The nuclei of fetal blood (human) are not very distinct. Fetal blood corpuscles are also larger than those of adults. White blood corpuscles are apparently of little significance in the identification of meats.

AVERAGE DIAMETERS OF RED BLOOD CORPUSCLES
(In microns)

I. Mammals. (Corpuscles circular and non-nucleated.)

1. Man	7 to 8.50
2. Musk deer	2.40
3. Horse	5.44
4. Cat	5.67
5. Hog	5.80
6. Ox	5.86
7. Dog	7.06
8. Orang	7.30
9. Chimpanzee	7.40
10. Elephant	9.20

II. Birds. (Corpuscles elliptical and nucleated).

1. Humming bird	9.40
2. Sparrow	11.21
3. Swallow	11.71
4. Turkey	12.22
5. Pigeon	12.67
6. Goose	13.40
7. Eagle	13.78
8. Swan	14.00
9. Owl	14.20

III. Fish. (Corpuscles elliptical and nucleated.)

1. Carp	11.50
2. Perch	12.00
3. Pike	12.50
4. Eel	14.50

IV. Reptiles. (Corpuscles elliptical and nucleated.)

1. Lizard	16.10
2. Viper	19.50
3. Tortoise	19.96
4. Turtle	20.31

V. Amphibians. (Corpuscles elliptical and nucleated.)

1. Frog	22.50
2. Toad	23.80
3. Siren	59.50
4. Proteus	62.50
5. Amphiuma	66.10

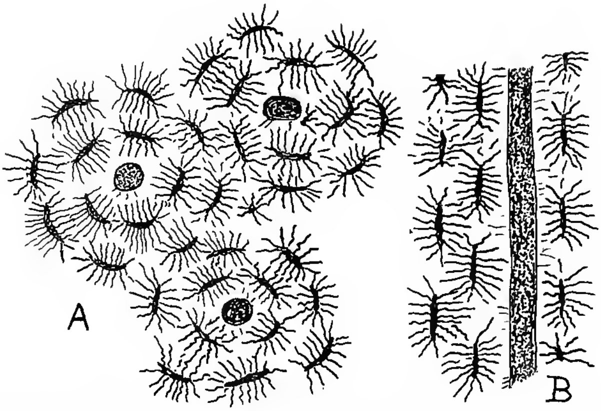

Fig. 53.—Microscopic structure of osseous tissue. A, transverse section showing Haversian canals, lacunæ and canaliculi; B, longitudinal section.

(*g*) **Dried Foods.**—Dry and dried foods, as cereals, flours, meals, ripe and dried beans, peas, lentils, and dried meats, dried vegetables, etc., are to be examined organoleptically and microscopically, for evidences of subdued decompositions (bacteria, molds, and very rarely yeasts), and for the presence of living or dead animal parasites (mites, laræ) and their excreta. The excreta of mites (in dried apricots, peaches, pears) have been mistaken for amebal resting forms. Toxin formers may occasionally be present and mold may be excessive. Dried meat may be moldy and may also contain bacteria in excessive numbers. Hams, shoulders, bacon, and dried meats, are apt to be moldy upon the exterior. The casings of sausages may be moldy or coated with coccus forms. If the bacterial contamination is not excessive, such meats are eaten after removing the mold infected portions.

Sliced dried beef, sliced bacon, and sliced tongue, put up in hermetically sealed glass jars, are apt to be badly contaminated by bacilli and several species of coccus forms (cocci and diplococci). The coccus forms resemble those so widely prevalent upon the exterior of sausage casings of sausages which are stored in damp places. Neither salting nor smoking inhibits the development of these organisms. The thin slices of meat in the glass jars and even the fat of bacon is frequently literally coated with these organisms, the number per gram of the meat, ranging from 50,000,000 to 12,000,000,000 and more. Such meat feels moist and more or less smeary, and has a peculiar musty and somewhat cheesy odor.

The Broca differential stain[1] is of great value in the examination of meats (dried, sliced, shredded) as it will indicate the proportion of living and dead bacteria. It will be found that the Gaertner group of bacilli are usually still viable in smoked and otherwise preserved meats. If, therefore, they occur in large number (in aggregates and stained a deep blue color) it indicates spoilage before curing or processing. Other bacilli and the diplococci are apparently much more resistant to the action of preservatives since they multiply after the preservatives have been added. In the canned sliced meats above referred to, stained slide mounts (Broca's stain) will show both dead and living forms. Sliced meats occasionally also show chains of true diplococcus forms imbedded in gelatine (*Diplococcus mesenteroides*) and these appear to be less resistant to the action of preservatives than are the coccurs farms.

(*h*) **Pastes.**—This includes vegetable, animal, and mixed pastes, also all kinds of potted and deviled meats. These foods are all to be looked upon with suspicion and should be very carefully examined microscopically. The organoleptic tests are frequently unreliable and inconclusive, because of the cooking, mixing, and spicing, which is employed. In brief, pastes are rather dangerous foods and should be avoided as much as possible. Potted meats and meat pastes are usually made up of several kinds of meats, mostly scraps and refuse, highly seasoned and spiced. Liver pastes (including pâté dé foie gras) and fish pastes are especially liable to be bad, due to bacterial decomposition. Fish pastes are usually made from scraps and trimmings and contain bacteria in great numbers. Tomato pastes are generally loaded with bacteria, spores, and mold, and occasionally also yeasts. Most of them are wholly unfit for consumption.

(*i*) **Meat Extracts and Meat Powders.**—Meat extracts may be adulterated with an excess of salt, with blood, with proteoses and peptones, with gelatin and egg albumin. Powdered meat preparations and so-called soluble meat (partially digested meat) powders and peptone powders are found upon the market. All of these articles require careful microscopical examination as they may be highly contaminated. Pemmican is a much used dry meat. Meat extracts are stimulating but their food value is extremely low.

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[1] Ten parts carbol fuchsin and 80 parts Loeffler's methylene violet. Let stand for several days before using.

On account of the presence of abundant organic particles which may be mistaken for microbes, smear preparations of meat extracts and of meat powders should be stained (Broca's stain) in order to distinguish the bacteria Many of the bacterial forms common in meat extracts are, however, distinctly recognizable without resorting to the use of stains. Dried meats may contain abundant agglutinated bacilli of the Gaertner group which must be stained in order to recognize them clearly.

(*j*) **Eggs.**—Practically all eggs are edible, whether from amphibians, reptiles, or birds. The roe of the shad and sturgeon, preserved in salt, forms the caviar of commerce. The roe of some fish is poisonous. The eggs of the turtle and terrapin are excellent. Ostrich eggs are found on the market in California. The eggs of all feathered animals may be eaten, and bulk for bulk, are about equal in food value, differing only in flavor.

Eggs appear upon the market whole (fresh laid, cold storage, preserved), frozen, and dried. Whole eggs are tested organoleptically, incidentally also microscopically; whereas frozen and dried eggs are examined microscopically, and incidentally also organoleptically.

The examination of whole eggs includes:

1. Physical inspection, as to size, cleanliness and marking or mottling of shell. Testing machines for size and weight.
2. Candle test.
3. Breaking test.
4. Odor test.

The following are some of the properties of good eggs.

1. The shells should be clean and free from mold stains and spots.
2. The candle test should show no dark spots and the air chamber should not be abnormally large.
3. On breaking, the contents should fall into a dish without rupturing the yolk, and neither the yolk nor the white should adhere to the shell. The yolk should be easily broken and should not be stiff or lumpy when stirred. The white should be nearly colorless and odorless.
4. The whites should not be yellowish or distinctly amber colored and should not be gelatinous.
5. The whites when stirred and allowed to stand for several minutes, should not have a mucous odor.

6. Good eggs are practically odorless.

7. Frozen eggs should not have a mucous or other bad odor.

Frozen eggs are not likely to be used in the army. Dried eggs (both whites and yolks), dried egg white and dried egg yolks, may be used. All dried egg substance should be carefully examined for possible excessive bacterial contamination. In yolks and admixtures of whites and yolks, the fat globules interfere with the ready counting of bacteria. In the whites the counting is very easy. Staining methods may be resorted to for the purpose of distinguishing between coccus forms and the cholesterin (fat) globules. The Broca or Giemsa stain will be found useful. If frozen eggs, after thawing and standing for a while, give off a marked mucous odor, they should be rejected without further examination.

An approximate bacterial count may be made from a stained slide. Make a dilution of 1:10, or 1:100, and from this make the usual slide smear which corresponds to a mount having a depth of approximately 0.05 mm. With a little practice smears representing that depth can be made fairly accurately. Let the smear air dry, fix with alcohol, stain for one or two minutes, wash in water, cover with cover glass and count at once, using an eye-piece counter (as Whipple), or the field of view. Let us suppose that a count of ten fields (oil immersion objective) shows an average of 30 bacteria (both dead and living, that is, living prior to staining) per field of view which field of view may equal 0.25 sq. mm. and therefore corresponding to a cubic area of 0.0125 cmm. (= $\frac{1}{80}$ cmm.), then the total number of bacteria per cc. of the egg material would be approximately 240,000,000, the dilution in this case having been 1:100.

The following suggestions are offered regarding the direct microscopical examination of eggs.

1. Fresh clean eggs show few bacteria; from 500, or less, to 50,000 per cc., or per gram.

2. Eggs in which the whites show from 1,000,000 to 10,000,000 bacteria per cc., or per gram, are no longer fresh and should be classed as not being strictly fresh, but still suitable for human consumption.

3. Eggs in which the whites, or the yolks, show from 10,000,000 to 50,000,000 bacteria per cc., should be classed as tainted, though still suitable for human consumption.

4. Storage eggs, frozen eggs, dried eggs, preserved eggs, etc., which show from 50,000,000 to 200,000,000 bacteria per cc., or per gram, should be classed as stale and should be used for baking and cooking purposes only.

5. Egg material in any form or condition whatsoever, which shows 200,000,000 or more bacteria per cc., or per gram, irrespective of whether said bacteria are dead or alive, should be rejected as unfit for human consumption.

6. Moldiness of egg shells, of egg membrane, of whites and of yolks, is readily detected by means of the compound microscope. Pronounced moldiness is also readily observable by the candling test. Moldy eggs have a musty odor or flavor and are unfit for human consumption.

7. The presumptive colon bacillus test is of little practical value in determining the freshness or the quality of eggs. Dirty eggs (exterior of shell) though newly laid, will show abundant colon bacilli of the avian type; clean fresh eggs will show comparatively few.

(*k*) **Bread and Pastry.**—Since these are usually prepared and baked in the camp, the microscopical and bacteriological examination pertains largely to those engaged in baking. Bakers and helpers must be in good health, cleanly in morals, in habit, and in dress, and must be non-carriers of disease. The containers and utensils employed must be clean and kept clean at all times.

Occasionally bread is found which is highly contaminated with bacteria and even mold, traceable to filthy mixing machines. Mold contaminated flour and meal may have been used. Ergot may be found in rye bread. The *Bacillus coli* group is common in cereals and in flours made therefrom. Typhoid bacilli have been traced to contaminated bread.

Bad eggs and worthless egg substitutes are used in pastry. Saffron is used to imitate egg color. Rancid nuts, moldy raisins, dirty currants, and spoiled figs, are used in cake. Old rancid lard may be used for shortening. Badly contaminated fillers for pies may be used. Mince meats are often highly contaminated. All these require the careful attention of the microanalyst.

Bread is raised by means of yeast organisms and the yeasts used may have been highly contaminated by bacteria. Protein granules and gluten and gliadin particles may be confused with bacteria, occasionally requiring the use of stains (Loeffler's methylene violet) or the differential stains already referred to.

IX. MICRO-ANALYTICAL RATING OF FOOD PRODUCTS

There is a universal preference for fresh foods, as free as possible from bacteria, yeasts, and molds. While there are still many unsolved problems regarding the spoilage of foods and poisoning from eating spoiled food, we are nevertheless warranted in setting fairly definite limits as to the unavoidable and permissible contamination of food supplies, and this despite the fact that we apparently eat with impunity certain food substances which are the product of microbic activity, as soured milk and cheese. There is no case on record where poisoning has resulted from eating moderately of fresh, non-anaphylactic, wholesome food, but on the other hand there have been innumerable instances of mild to fatal intoxications following the ingestion of spoiled or microbially decomposed foods. It is these all too frequent occurrences which warrant us in setting a limit as to the number of bacteria, yeasts, and mold which may be considered safe. What shall these limits be? It is universal practice to place the danger signal within the zone of safety, not beyond it. Furthermore, we place the danger signal as soon as the danger is sighted, or is known to exist. We do not wait until the accident or mishap or catastrophe shall first have occurred. On the other hand, it is universally admitted that there are no danger signals required where there is no danger. Such signals would not only be useless, but they would cause unnecessary confusion, worry, and anxiety. To condemn all foods which contain bacteria would be absurd and not to condemn foods which contain bacteria and other organisms to a dangerous degree, would be inexcusable and criminal.

The following is a summarizing statement of food decomposition from the viewpoint of the public health and the practicably attainable in manufacture.

1. Fresh wholesome foods free from all microbial decomposition changes are best for the human race. This has been demonstrated to the satisfaction of all scientists. The exceptions to this are the comparatively small number of fermented foods, such as sour milk, cheese, Sauerkraut.

2. It is not practicable to supply foods which are entirely free from all organisms of decomposition.

3. While there is no evidence of injurious effects from the

ingestion (with our foods) of comparatively small numbers of contaminating organisms, the ill effects of highly decomposed foods are universally recognized.

4. It is clearly the duty of those entrusted with the maintenance of the public health to see to it that the following conditions prevail as to food supplies.

(*a*) That all food supplies intended for human consumption are free from harmful decomposition changes.

(*b*) That all food substances intended for human consumption do not contain excessive numbers of microbial organisms, irrespective as to whether they are harmful or not.

(*c*) That those engaged in supplying foods for human consumption use the modern scientific methods which will render the food as free as possible from organisms of decomposition.

(*d*) Any food substance which cannot be kept free from excessive decomposition by any of the applicable modern scientific methods, should not be used for human consumption.

(*e*) Of the socalled fermented foods (cheese, sour milk, Sauerkraut, yeast, Soja sauce), including those in which some of the preparatory changes are fermentative in nature (bread), only those should be used which have been proven harmless and free from objectionable secondary fermentative and decomposition changes. The same statements also apply to fermented drinks of all kinds.

5. From the above it becomes apparent that food analysts and those entrusted with the administration of the pure foods laws should be very largely guided by the following.

(*a*) Have the manufacturers, packers and canners taken every precaution to keep food articles free from decomposition?

(*b*) Is the food article free from harmful contamination?

(*c*) Does the food article contain microbial contamination in negligible, non-harmful, or permissible numbers only?

The following maximum numerical count limits (of bacteria, yeasts, mold) for food substances are based upon many years of experience in the microscopical and bacteriological examination of food supplies and are believed to be fair to the manufacturer and dealer and safe for the consumer.

It is, however, desired to state that the numerical counts of bacteria, yeasts, spores and mold hyphæ in the various food substances mentioned and described in the following pages, are in no wise intended as standards or definitely fixed numerical limits. They are to serve as a guide for the field microanalyst in formulating decisions as to the quality of the food substances intended for army use.

The numerical counts are made intentionally somewhat high (therefore, not representing a high grade or quality of food), in common with the universal system of standardization. That is, a standard, be it of food or drug, must be sufficiently low so as to make the average article acceptable. It is, however, also understood that any and all food standards, no matter how low, must be wholly within the zone of safety, as has been emphasized again and again in these pages.

It will be found that some of the counts given are somewhat lower (note tomato products) than those which are generally adopted as limits in civilian laboratories, not that the soldier is especially in need of a higher grade of food than is the civilian, but rather the suggested standards are made somewhat higher because of the fact that the army food microanalyst is obliged to work rapidly and give his decision promptly. Therefore, in order to be on the safe side, he should pass or approve such food substances only as are well within the zone of safety, rather than on the side of doubt or uncertainty. Occasions will time and again arise when even the field analyst must proceed slowly and thoroughly, as when food supplies run very low or when a large quantity of an important food article is concerned. In such cases he must make careful organoleptic and microanalytical tests, even resorting to animal feeding tests, and trial testing, nibbling and feeding tests upon humans (somewhat as in the physiological testing of mushrooms). While it is strongly advised to reject all food substances which are poisonous or otherwise objectionable in the *raw* or *uncooked* state, yet exceptions may be made. For example, *thoroughly* cooked tubercular meat may be eaten, also *thoroughly* cooked trichinous meat. It is, however, inadvisable to chance eating food infected with the toxin of the *Bacillus botulinus,* no matter how long or how thoroughly cooked, and this despite the fact that this toxin as well as the organism (inclusive of the spores), forming the toxin, is said to be destroyed at a temperature of 80°C.

Despite the fact that the standards herein proposed are, as stated, somewhat low rather than high (that is, low for a first quality food), it is believed that in time, after we have had time to make more extended observations in food decomposition and on food production and food preservation, the counts will be greatly lowered. It should be the aim of all producers, handlers, and sellers of foods to so improve upon methods so as to gradually reduce the contaminations, decompositions and infections, to *wholly negligible amounts.*

The food materials and beverages are briefly treated as follows.

1. General microscopical and physical characters.
2. Special identifying characters based upon microscopical examination.
3. Numerical limits of bacteria, yeasts, and mold.
4. Most likely adulterants and their microscopical characteristics; and the special properties and uses of each food substance or of each group of food substances.

1. Alcohol and Alcoholic Beverages

Alcohol (ethyl and methyl) has a use as preservative of museum and anatomical specimens, and in the arts and sciences. Wood alcohol is poisonous and is not to be given internally nor applied externally. Alcoholic beverages have a limited use in medicine, but have no use in health. Alcohol is a plasmic poison and, even in small doses, depresses the higher nerve centers. Hot whiskey and brandy are reputed to have diaphoretic and diuretic properties. Hot water is, however, even more effective and is without toxic effects. Alcohol does act as a circulatory stimulant, but even in this regard it is inferior to other agents which have little or no toxic effects.

Beers, porters, wines, saké, and other brewed beverages, often become diseased through the advent of wild yeasts and other objectionable micro-organisms. The taste and flavor is altered and they may become turbid and changed in color.

Whiskey is usually made from corn by fermentation and distillation, while brandy is made from fruits (largely grapes) by fermentation and distillation. Cordials are compounds of alcohol (whisky or brandy), sugar and fruit flavor or fruit juice.

In general, alcoholic beverages have no place in the army, or in any social organization, as is now generally admitted. The use of alcoholic beverages always makes for inefficiency and never for efficiency.

2. Apples; green, ripe, and dried. *Pyrus malus*

1. *General.*—Green (unripe) apples show more or less starch, whereas ripe apples contain practically no starch. The pulp cells are large, cell-walls rather thick, colorless, and without distinctive contents. The micro-sublimation test shows a faint trace of benzoic acid.

2. *Special.*—The window cells of the epidermis are quite characteristic (15 to 50μ) (Fig. 60) and the epidermal cells may contain coloring substances (chlorophyll granules in green apples, red and brownish coloring matter in ripe apples). The window cells are

similar in the different varieties of apples. Similar window cells appear in the quince, plum, pear and almond.

3. *Ratings.*

	Number per cc.		Mold. Per cent. of fields
	Bacteria	Yeasts	
(*a*) Green apples	Negligible	Negligible	Negligible.
(*b*) Ripe apples	Few	Few	1–3 per cent.
(*c*) Dried apples	500,000 to 1,000,000 to	Few	2–5 per cent.
(*d*) Apple jam	10,000,000 40,000,000	500,000 to 5,000,000	Not to exceed 10 per cent.

4. *Adulterants.*—Comparatively rare as to (*a*) and (*b*), substitution and false claims as to variety may be made. Pears and quince may be added to (*c*) and (*d*). Reject (*c*) if mites are present in considerable numbers (look for living or dead insects and their excreta). Apples may be excessively worm infested, and may show arsenical spray burns. Rotted, overripe, over-ripened and frozen apples should be rejected. Unripe apples should not be eaten raw.

Fresh (unfermented) cider is mildly laxative. Hard cider is bad for the digestion. Bottled ciders usually contain preservatives (generally salicylic acid). Bulk apple pie stocks are frequently unfit for human consumption because of bad apples used and because of yeasts, mold, and bacteria present.

3. **Apricots; Green, Ripe, and Dried.** *Prunus armeniaca*

1. *General.*—Apricots differ in size, taste and flavor. Green apricots contain some starch. Ripe apricots contain no starch.

2. *Special.*—The epidermis contains abundant single-celled, somewhat bent and curved, widened at the base and rather short, trichomes (compare with those of peach and quince). (Fig. 65.) The epidermal cells proper contain little or no coloring matter. Green apricot pits contain oil and the seeds are used in making so-called "almond pastes." The seeds are also used for the purpose of adulterating almonds.

4. *Adulterations.*—Rare; dried apricots and dried peaches may be confused by the careless and ignorant. Bleaching may be practiced to hide spoilage and other defects. This fruit spoils easily and overripens quickly. (*c*) is rare in the United States, much used in Turkey and Syria, to some extent in Europe. (*b*) is apt to be in-

	Number per cc.		Mold. Per cent. of fields
	Bacteria	Yeasts	
(*a*) Ripe apricots	Few	Few	1–3 per cent.
(*b*) Dried apricots	25,000,000	10,000,000	Not over 5 per cent.
(*c*) Apricot paste	100,000,000	40,000,000	Not over 20 per cent.
(*d*) Apricot jam	50,000,000	25,000,000	Not over 10 per cent.

fested by mites. Apricot cordial has a pleasing flavor and aroma. Ripe apricots are nourishing and mildly laxative. Pies made from dried apricots are popular and apricot jam is well liked.

4. Bananas; Ripe, Green, Dried, Meal. *Musa sapientum*

1. *General.*—Tropical fruit. Usually picked (the bunches) while green and allowed to ripen in shipment and during temporary storage. Quite rich in rather large, irregular, distinctly lamellate starch granules with hili eccentric, near the narrower end. Large thin walled, loosely united pulp cells.

2. *Special.*—The most distinctive microscopical characteristic are the starch granules. In the banana meal, the pulp cells are much broken up (Fig. 60–2).

3. *Ratings.*—Bananas (fresh, ripe) are readily attacked by mold, less commonly by bacteria, yeasts, and amebæ. The amebæ are the last to make their appearance. Ripe bananas form a rich food. Green bananas are very difficult to digest and should not be eaten. Bananas (green and ripe) are under suspicion of being carriers of amebic dysentery.

Ripe bananas rot quickly unless kept in a dry cool place. The banana meal keeps fairly well if kept dry and stored in a dry cool place. The chief nutrients of bananas are sugar and starch. They contain very little fat or proteins.

4. *Adulterations.*—Bananas are not adulterated. There are a number of varieties. The meal may be adulterated with cereal and potato.

5. Beans; String Beans, Green Beans, Pickled, Baked, and Canned Beans, Bean Flour. *Phaseolus vulgaris* and Cultural Varieties

1. *General.*—The innumerable varieties differ in size, form, and color. They are rich in starch and also contain protein granules. Beans have a characteristic odor. Eating beans causes flatulence.

2. *Special.*—The starch granules are large, kidney-shaped, with prominent fissured hili. The epidermal cells (palisade cells) differ more or less in the different varieties and are the means of distinguishing this seed from the related pea, lentil and soy bean. (Fig. 54).

3. *Ratings.*—In the presence of sufficient moisture and warmth, beans decompose quite readily, usually with the liberation of H_2S gas. Pickled and canned string beans (especially if canned by the "cold process") have been found to be highly toxic, due to the presence of the *Bacillus botulinus.* All canned beans and other canned foods containing bean additions, should be carefully examined.

	Bacteria (per cc.)	Yeasts (per cc.)	Mold (per cent. of fields)
(*a*) String beans	25,000,000[1]	Few	Few
(*b*) Baked beans	25,000,000[1]	Few	Few
(*c*) Ripe beans	Few	None	1–2 per cent.
(*d*) Bean flour	5,000,000	None	1–2 per cent.

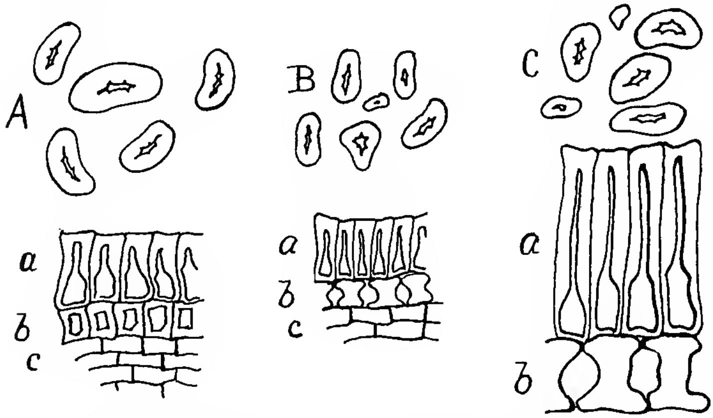

FIG. 54.—Leguminous starches and seed coat tissues. A, bean starch; *a*, epidermal (testa) palisade cells; *b*, crystals bearing hypodermal cells; *c*, hypodermal parenchyma. B, lentil starch; *a*, palisade tissue; *b*, hour glass cells of the hypoderm. C, horse bean starch; *a*, palisade layer; *b*, hour glass cells. The differences in the size and form of the cells of the seed coat (testa) are very important in the identification of the different members of the bean family.

5. *Adulterations.*—(*b*), (*c*), and (*d*) may contain an excess of defective beans or moldy beans, (*c*) and (*d*) may contain insect parasites. Varieties may be substituted. String beans may be excessively stringy and inedible. String beans may be colored

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[1] If spore-bearing bacilli are found to the number of 5,000,000 per cc., or more per gram, the article should be rejected.

artificially (sulphate of copper). Frost bitten beans may be dried and made into meal. Well ripened thoroughly dried beans keep well and should contain few moldy, shrivelled, or discolored seeds. The defective beans should be removed by the water gravity method.

Beans form a very important food and they occur in great variety, differing in form, size and coloring. Snap or string beans are the unripe pods (pericarp) inclusive of the beans or seeds. The horse bean of California (*Faba vulgaris*) is intended as animal feed, but may be eaten by humans. Canned horse beans (string) have recently appeared on the market. They have a peculiar rather strong flavor. The Soya bean (*Glycine hispida*) is much used as food in China and other Oriental countries, and has recently been introduced into the United States (California and Southern States) and other countries. It contains practically no starch, is rich in proteins and in oil (the oil is used in the arts, in soap making and as a salad oil). The Lima bean (*Phaseolus lunatus*) is liked because of its flavor. It forms an ingredient of the Indian dish succotash. The broad bean (*Vicia faba*) is the oldest cultivated bean. The common bean (*Phaseolus vulgaris*) with its numerous varietal forms, is cultivated in all civilized countries. The immature pods are cooked, pickled, dried, and preserved. The cow pea (*Vigna catjang*) is quite popular in most countries, used and prepared much like ordinary beans. To the bean family also belong the tamarind (*Tamarindus indica*), the seeds of which are eaten, and the pericarp is used as a laxative and in fevers; St. John's bread or locust bean (*Ceratonia siliqua*), found in most drug stores. The pod of St. John's bread is sweet and is eaten raw.

Canned beans are of great importance to the analyst, more especially canned string beans, because, it would appear that highly toxic forms of the *Bacillus botulinus* group are not uncommon in them, more especially if put up by the cold process (Dixon). All canned string beans should be carefully examined for bacteria and endospores. All canned beans which show 5,000,000, or more, endospores per cc. should be rejected. All soft, squashy or sour ("flat sours") string beans should be rejected without further examination; likewise all canned string beans of a vivid green color (use of copper).[1] Canned beans, canned pork and beans, bean soups, and soup stocks with beans, and other canned combinations of beans with meat and vegetables, should be carefully examined microscopically for bacilli (with or without spores). Feeding tests with domestic fowls may be made in case of canned string beans showing bacilli and endospores and which are suspected of harboring representatives of the sausage bacillus group.

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[1] The following simple microanalytical test for copper may be made.

Place a bit of very fine powder of hematoxylon wood upon a clean slide and mix it with a drop of the solution suspected of containing copper. If copper is present, the particles of hematoxylon tissue will gradually assume a blue coloration. Warming the slide hastens the color change. The test is a very delicate one. The smallest tissue particles show the color changes first, and these are the only particles which will show such changes in the presence of the merest trace of copper.

The fruit (pod with seeds) of the bean plants is eaten (cooked) before maturity and the seeds are eaten in all stages of development. String beans may also be pickled and dried. In Germany string beans (with salt added) are allowed to ferment (in the manner of Sauerkraut) and used as food. The Oriental use various fermented bean products, as soy sauce, natto, miso, and tofu.

6. Beverages

(*a*) **Water.** 1. *General.*—Good drinking water should be odorless and tasteless, cool, well aerated, entirely clear and colorless, and should not contain an excess of mineral matter, and only small amounts of organic matter.

2. *Special.*—Pure water reveals nothing under the compound microscope; however, absolutely pure water supplies do not exist in nature. The general contaminations found in water supplies have already been mentioned.

3. *Ratings.*—The contaminations of drinking water have already been mentioned and from which it will be evident that it is difficult to give definite ratings for water supplies. The following will serve as suggestions to sanitarians.

	Bacteria per cc.	Algæ per cc.	Mold and spores
Drinking water	500 to 1000	500 to 500,000	None
Washing and cooking	15,000,000	5,000,000	Trace
For animals	15,000,000	15,000,000	Few
For irrigation	5,000,000,000	25,000,000 or more	Few to many

The analyst must give heed to the following groups of organisms in water supplies.

(*a*) Diatoms and desmids indicate surface seepage and also high percentage of organic matter.

(*b*) The presence of blue green algæ (Oscillaria and Nostoc) indicate mud and ooze from swampy soils.

(*c*) Protozoa (Paramecia, Amebæ, Bell animalculæ, Ciliata, Flagellata) indicate the presence of abundant organic matter and decaying organic matter. The bacterial count will be very high.

(*d*) Mold hyphæ and spores indicate contamination with decaying vegetable matter.

(*e*) The bacteria count will be found high in proportion to the general contamination (from soil, sewage, decaying matter).

(*f*) Hydras, small crustaceans (Cyclops, Daphnia), and other minute animal life, are sure indicators of heavy contamination with decay, both animal and vegetable.

(*g*) Insects (water beans, skaters, etc.) appear in and upon shallow water supplies (the quieter edge of streams, ponds, near springs, etc.) and do not necessarily indicate dangerous contamination.

(*h*) Streptococci, Leptothrix and Crenothrix forms indicate sewage contamination and such waters call for special chemical and mechanical treatment to render them potable.

Drinking water which contains an excess of magnesium and iron salts causes the stools to turn dark to nearly black. Excess of lime encourages calcification. Distilled water is objectionable because deficient in mineral matter and also because it disturbs the osmotic balance of the cells (of the alimentary tract), acting as a mechanical poison.

(*b*) **Coffee.** *Caffea arabica.* 1. *General.*—The bean (seed) is composed of rather thick walled (walls porous) parenchyma cells (endosperm). There are no starch granules, no crystals, and no distinctive cell-contents.

2. *Special.*—A certain number of quite characteristic bast-like sclerenchyma cells are always present in ground coffee. The porous walls of the endosperm cells are quite characteristic. In roasted coffees the parenchyma elements are brown in color, hard and brittle.

3. *Rating.*—Coffees differ in aroma and in the percentage of caffeine which they contain. The aroma, which is developed on roasting, may be bad, poor, fair, good, or excellent. Coffee is quite free from bacteria and other microbic contaminations.

4. *Adulterations.*—These are common and in great variety. The raw beans have been colored with Prussian blue, and adulterated with pebbles, beans, and other seeds. Imitation coffee beans have been made from pressed clay. The roasted beans are less likely to be adulterated. Roasted soy beans, Garbanza beans, and other leguminous seeds have been added. The grossest adulterations exist in ground coffee and vary from complete substitution to vary-

ing degrees of admixtures of many kinds. The following are the more common adulterants. Roasted cereals, bran, chaff, coffee hulls, figs, prunes, chicory, dandelion root, beet root, cornmeal, and exhausted coffee (coffee grounds).

The following is a brief summary of the physiological action and properties of coffee.

(*a*) It is a true stimulant of the higher faculties.

(*b*) It is a heart and respiratory stimulant.

(*c*) It has marked diuretic properties.

(*d*) It has antiseptic properties, due to the aromatic oils which are developed on roasting.

The prolonged use and excessive use of coffee gives rise to toxic effects, referable to the nervous system, manifesting themselves in disturbed sleep, functional heart disturbance, and in various forms of nervousness. The toxic symptoms disappear entirely, without leaving any after effects, soon after its use is discontinued. One or two cups of good coffee per day may not give rise to toxic symptoms, and again this amount may be excessive for some persons. Coffee should be made by the percolation method, and should never be boiled for more than a minute or two. A cup of hot coffee (with cream, or condensed milk, or boiled milk, and sugar to suit) is a pleasing drink and is a wonderful stimulant to brain and heart.

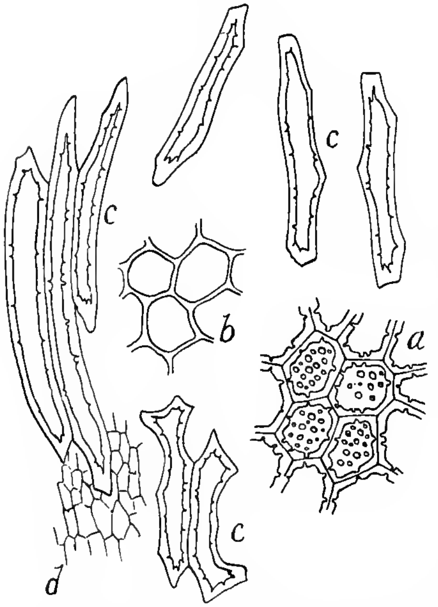

FIG. 55.—The diagnostic tissue elements of coffee. *a*, the endosperm cells containing protein granules and oil particles; *c*, sclerenchymatous bast fibers of the chaff. Ground coffee is adulterated with a variety of substances.

(*c*) **Tea.** *Thea sinensis.*—1. *General.*—The leaves differ in size (immature to mature), and in coloration. The fermented leaf is darker than the unfermented leaf. The leaves are partially dried, fired, and variously rolled and then completely dried. Flavors may be added (flowers, as in Pekoe tea). There are many commercial varieties.

2. *Special.*—The single-celled rather thick-walled trichomes and the branching sclerenchyma cells of the tea leaf, are quite diagnostic. Spiral ducts are abundant.

3. *Ratings.*—The Amercian Tea Commission sets the tea standards, and the tests for the several standard teas are made by expert tea tasters. The leaves are fairly free from bacteria, mold and other organic contaminations. Tea should be free from fish flavor or aroma.

4. *Adulterations.*—Leaves from related plants and from plants not related, are used as adulterants. Old worthless tea leaves may be added. Exhausted leaves are dried and re-rolled. Artificial coloring (Prussian blue, indigo) is no longer permissible in the United States. The color tests (Reid and West) are simple and easily applied.

Tea is also a cerebral stimulant and diuretic. It is, however, not equal to coffee as a brain and heart stimulant. Tea should not be boiled. The use of long boiled tea causes dyspepsia (due to the tannic acid). Tea appears to have little or no antiseptic properties. The Chinese are adepts in tea making. Tea is made as follows: Into a cup place a pinch (2 grams) of the preferred variety of tea, fill up with water near (not at) the boiling point, let stand for two to three minutes, decant and drink.

The familiar and popular diaphoretic teas, as chamomile (German, Roman, Californian, etc.), ginger, sassafras, etc., are not true tea substitutes. Paraguay tea (Maté) is a substitute for tea, containing caffeine and having similar properties. Tea is made from mint, from horehound, from spruce and hemlock branches, from sassafras bark, etc., for special purposes. The infusions of the medicinal herbs are commonly spoken of as teas.

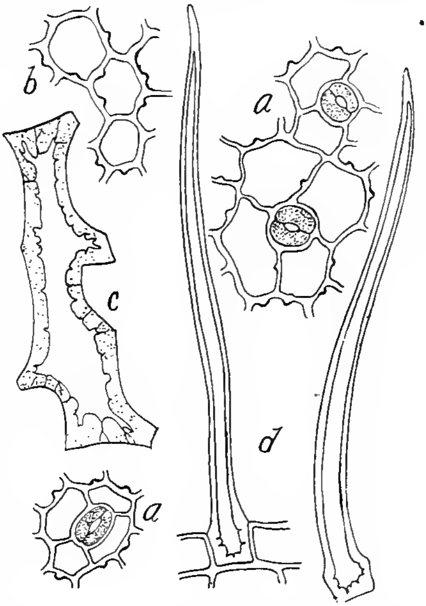

FIG. 56.—Tea. *a*, epidermal cells showing stomata; *b*, lower epidermis; *c*, a large sclerenchyma cell from the leaf parenchyma; *d*, trichomes. Tea is frequently adulterated with foreign leaves and other vegetable substances, exhausted leaves, etc.

(*d*) **Chocolate and Cacao (Cocoa).** *Theobroma cacao.*—1. *General.*—The seed proper consists of parenchyma cells which are small, rather thin-walled and usually much broken up in the chocolates and cocoas (cacaos). The cells contain some starch and abundant fat (cocoa butter), which latter is partially removed in cocoa.

2. *Special.*—The brown coloration is characteristic. The starch granules are rather small, simple and compound, and non-characteristic. Some shell tissue is usually present, often in excess (from 5 to 20 per cent.). Spiral ducts, if abundant, point to shell excess.

3. *Rating.*—The commercial varieties of cocoa and chocolate differ somewhat in flavor and aroma and in the degree of bitterness and astringency. Bacteria are sparingly present and any considerable mold contamination is uncommon. Both cocoa and chocolate may be sweetened with 40 per cent., or more, of sugar. The so-called soluble cocoas are treated with an alkali, but to speak of them as soluble is incorrect.

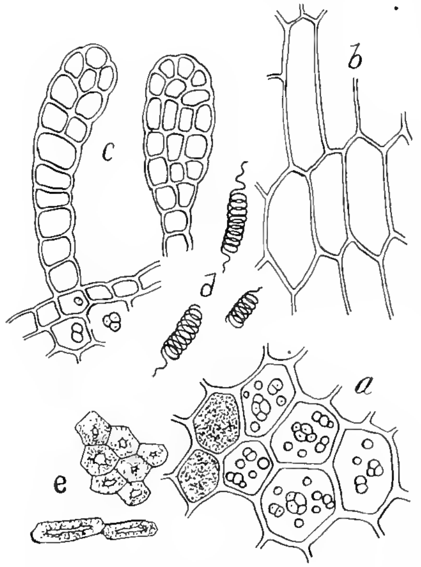

Fig. 57.—Cocoa. *a*, endosperm cells with starch, usually very much broken up in ground cocoa; *b*, parenchyma cells of the shell; *c*, trichomes which are few and not diagnostic; *d*, spiral ducts of the shell tissue; *e*, sclerenchyma cells of the shell tissue. May be adulterated with other tissues and an excess of shell tissue. Cocoas contain from five to twenty per cent. of stems.

4. *Adulterations.*—The most common adulterant is cocoa shells. Sugar may be in excess. Roasted acorns, chestnuts, cereals, and beans are said to have been used as adulterants. Cocoa butter and other fats may be added to chocolate.

The drink made from either chocolate or cocoa is mildly stimulating (due to the active constituent theobromine), and it has marked food value, especially if sugar is added, and also has diuretic properties. The cocoa butter present appears to be difficult to digest and may give rise to symptoms of dyspepsia. Sweet chocolate and chocolate confections are nourishing as well as heat and energy producing and mildly stimulating, especially valued on the march. The stimulating properties of cocoa are far less marked than those of either coffee or tea.

The experienced micro-analyst can estimate the percentage of shells present with considerable accuracy. The shell fragments (inclusive of same sclerenchyma cells) are deep brown and coarser than the endosperm fragments. The germ tissue resembles that of the endosperm. The shell tissue contains numerous spiral ducts.

(*e*) **Substitutes.**—Substitutes for coffee are legion and every one of them is a delusion. Not one of them is worthy of the serious consideration of persons of intelligence and yet many substitutes are found on the market, made from a variety of substances, as roasted cereal (wheat, rye, barley), roasted bran, roasted acorns, roasted sun flower seeds, carrots, beets, etc. Chicory is much used as a coffee substitute in France and in Germany, and many relish the chicory flavor in coffee. Attempts have been made to collect and condense the aromas escaping from the coffee roasting drums in order to use them in making coffee substitutes and to add them to coffees with insufficient or poor flavors or aromas, but so far with no great success.

A 10 per cent. coffee infusion inhibits the growth of the colon bacillus (Gupta) and the antiseptic properties of coffee are attested to by numerous investigators (Tavera, Ellis).

Among the substitutes for tea and coffee used in various countries are:

(*a*) *Mate or Paraguay Tea.* This consists of the leaves of *Ilez paraguayensis*, a holly-like bush of South America (Paraguay, Brazil, and other states). The leaves contain from 0.5 to 2.0 per cent. caffein. The drink is bitter, astringent and aromatic.

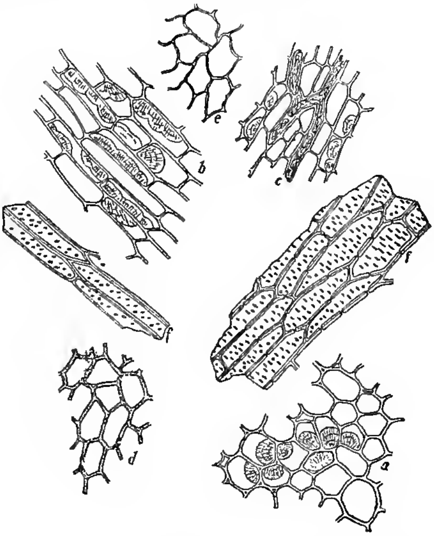

FIG. 58.—Chicory (*Cichorium intybus*). *a*, inulin bearing parenchyma cells; *b*, parenchyma, longitudinal view; *c*, laticiferous ducts; *e*, parenchyma; *f*, tracheids. Chicory is much used as a substitute for and an adulterant of ground coffee.

(*b*) *Khat.*—Made from the leaves of an Arabian shrub (*Catha edulis*). The active principle katin has stimulating properties similar to those of caffein.

(*c*) *Kola Nut.*—The seeds of *Sterculia acuminata* contain caffein (Africa, East India, Jamaica, Ceylon, Brazil). The drink made from the fermented, dried and ground seeds is said to have remakable sustaining properties. It is an ingredient of the soda fountain drink "Koka-Cola."

(*d*) *Guarana.*—The crushed seeds of *Paullinia cupana* made into a paste, moulded into ticks and dried. It is rich in caffein.

(*e*) *Coca.*—The leaves of *Erythroxylon coca*, a South American shrub, long known and used as a stimulant and from which the local anæsthetic cocaine is obtained. The natives of Peru have used the leaves as a stimulating masticatory for many centuries.

7. Breads

1. *General.*—Bread is made from finely ground cereals, principally wheat, from which the bran has been removed. At the present time the roller process of making flour is almost universally employed, by which process about 75 per cent. of the wheat grain enters into the flour, about 25 per cent. being excluded as bran and "offal."

American war time bread was made from wheat flour with admixtures of barley flour, corn flour, and rice flour, the admixtures usually amounting to 25 per cent.

Bakery breads may contain bacteria in considerable number (traceable to dirty mixing tables, dirty mixing machines, long standing dough, etc.), also dirt and contaminations from dirty hands, dirty flour used, etc. Breads containing additions of flour from Kaffir corn, Egyptian corn, dirty wheat, rye, and barley, may contain considerable sand and dirt.

2. *Special.*—After the baking, the starch of the bread is considerably distorted in form, but the identity of the granules is still recognizable. The granules are least distorted in the brown crust. Other flour elements as trichomes, broken parenchyma cells, and gluten bearing tissues are very little changed. Yeast raised bread will show yeast cells and also a certain number of bacteria, traceable to the usually impure yeast. Other bacteria traceable to hands, tables, mixing machines, etc., have already been mentioned.

It is difficult to recognize admixtures of rye, wheat, and barley flours in the finished bread. The so-called potato breads, as a rule, contain no potato.

3. *Ratings.*—Bread should not have a sour or sourish taste, or odor, and should not contain more than 20,000,000 bacteria per gram (use Broca stain). There should be no mold present and the odor should not be musty. Stale bread, provided it is not moldy, may be toasted or made into bread pudding, or freshened by steaming.

Breads of different countries may contain (in addition to wheat flour) corn flour, rye flour, barley flour, rice flour, chestnut flour, sago, arrowroot, pea, bean, and lentil flour, besides other starch bearing vegetable substances. The microanalyst is frequently called upon to determine the composition of flours, of doughs, and of breads of all kinds.

4. *Adulterations.*—Breads are not generally adulterated. Sand and dirt may be in excess. The milling grades of flour may not always be correctly declared or stated. Milling "offal" and screenings may be used. In times of stress, "red dog" (a very poor grade of flour), winnowings, bran, chaff and even barn sweepings, have been and may be used in bread making.

5. *Bread Diseases.*—Since the appearance of the so-called war breads, made from various combinations of flours, as wheat mixed with variable amounts of other cereal flours (rye, barley, rice, millet), flours from whole wheat (Graham flour), from whole rye, corn, Kaffir corn, buckwheat, etc., and admixtures of these with other flours, and additions of other starchy flours, as potato, sweet potato, peas, lentils, etc., has resulted in the reappearance of old bread troubles of various kinds, as sour bread, ropy bread, blood bread, blue bread, moldy bread, etc. The long established preference for white wheat flour for bread making is not a mere fad, or a perverted taste for an impoverished food, as is claimed by some dietitians, but is rather based upon the sanitary observations of the past. It was found that the omission of the bran, much of the dirt, sand and certain more or less irritating and indigestible tissue element (trichomes and epidermal cells) and various infections were also excluded, and bread difficulties became reduced.

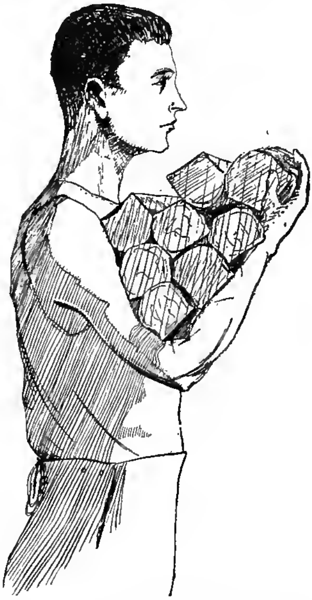

FIG. 59.—A careless mess cook carrying bread on his bare arms. —(*Pryor.*)

The two most serious bread diseases which have recently made their appearance in American bakeries, are sour bread and ropy bread (sticky bread, stringy bread). The former is more general in home baking, the latter is more common in bakeries. Both are due to bacterial invasion. Of these two, ropiness is the more important disease, as it is the more widespread and the more difficult to combat.

There are all gradations from an ideal loaf of bread, light, soft, spongy and quite dry, with an agreeable odor and taste, through more or less heavy and moist to distinctly soggy and sour, bread.

Bread deterioration may be due to poor yeast or bacterially contaminated yeast, or to the use of home made yeast dough (especially if mixed with potato) and also due to the use of dirty and contaminated flours. Trouble may arise from defective dough fermentation (rising). If the fermentation is prolonged, or hastened by raising the temperature unduly, acid formers (lactic, acetic, butyric) gain the ascendency and the souring of the dough and of the bread made therefrom, is the outcome, with the resultant deterioration in the consistency, and in the flavor of the baked loaf.

Souring of dough and bread is readily prevented by using pure white flour, or Graham flour made from well-ripened clean grain, with pure yeast and carefully regulating the rising and baking processes.

Mold is common in bread which is kept in damp places. The infection usually enters from the air, though it may also be traceable to dirty containers and dirty mixing machines. Species of Penicillium and of Mucor develop readily upon the damp crust and the cut surfaces of the loaf. Moldiness is readily detected by the odor and also by the color (blue, gray, black).

Ropy bread has been observed for a long time. It is so-called, because the interior of the bread at first becomes sticky, finally stringy or ropy. It is a bacterial disease (the primary cause being the *Bacillus mesentericus*, or *B. mesentericus fuscus*). In the baking the organisms (inclusive of the spores) near the exterior of the loaf (about ⅓ of entire loaf) are killed; whereas the temperature in the interior of the loaf is just enough to incubate the spores so that an extensive bacterial growth has taken place by the time the loaf is cool (3 to 6 hours), although a retarded multiplication continues after the loaf is reduced to the temperature of the surrounding atmosphere, until finally the entire loaf is affected in the manner above indicated. The spores of this bacillus are highly resistant to high temperatures, surviving boiling for some time (30 minutes to several hours). The portion of the loaf affected finally changes in color (grayish to brownish) giving off a very peculiar odor (variously designated as musty, disagreeable, valerian-like, hen-coop like, etc.) and gradually developing a bitter, disagreeable taste. The bacillus belongs to the so-called potato group, develops readily on potato and on many other media. It finds its way into the dough and bread from the air, from the soil, from contaminated water (soil seepage), from white flour (especially cheap flours), from Graham flour, barley flour, potato flour, from contaminated bread yeasts and also from contaminated salt; but by far most commonly from dirty mixing machines. The following are some additional factors concerned in encouraging ropiness in bread.

(*a*) The use of mixtures of different kinds of flours, especially the poorer quality whole grain flours.

(*b*) The use of poor, dirty and defective cereals in making flours.

(*c*) The use of defective yeast or sour dough. Some of the market yeasts are not pure, being contaminated by wild yeasts and bacteria of various kinds.

(*d*) Some of the market salts are highly contaminated by bacteria, including sporogenous forms, among them *B. mesentericus.*

When ropiness in bread has once made its appearance in a bakery it is not readily eradicated, because the primary cause is a spore former and the spores are killed with great difficulty. A very thorough cleansing must be done. Every nook and corner of the entire equipment with which the dough and diseased bread has come in contact must be scraped, cleaned, washed and repeatedly steamed; them dried, exposed to sunlight and again washed and steamed.

Watkins, who has made a special study of ropiness in bread, recommends that doubtful flours be tested for the presence of the ropy bread bacillus, before using such flours for bread making. Place a teaspoonful of the flour to be tested in a beaker and mix with 25 cc. of distilled water. Boil for 20 minutes. Break open a good loaf of bread, known to be free from ropiness, and inoculate the interior with the hot flour infusion and incubate at 35° to 40°C. for 48 hours. If ropiness develops the flour should be rejected. Boiling the flour in water kills all bacteria with the exception of the resistant spores which survive. Of course, the usual precautions against outside contamination must be observed in making this test.

The organism causing ropiness in bread is very widely distributed in soils, in surface water, in sewage, in cerals of all kinds, upon roots, tubers, bulbs and fruits. The trouble arising from the *B. mesentericus* group is in direct proportion to lack of cleanliness and of sanitation in bread making and inversely proportional to the quality and purity of all of the ingredients used in bread making.

Housewives occasionally have trouble with the yeast used in bread-making (sour, stringy, with bad odor) and the rising of the dough is insufficient and the baked loaf is heavy, hard and soggy, with a sour odor and a sourish bitter taste. The microscopical examination of such breads will reveal abundant bacteria, and the usual yeasts. The microscopical examination of ropy bread will show that the interior of the loaf contains practically a pure culture of the causative bacillus.

The bacillus of ropy bread does not appear to be influenced by the yeast organisms nor is it a symbiont with other species of bacteria. It develops best at a comparatively high temperature (37° to 40°C.).

The probabilities are, that if proper attention is given to sanitation in and about the bakery, and seeing to it that the flour used is good (clean, quite free from dirt, spores, mold and bacteria), and baking the bread thoroughly, cooling it quickly and keeping it in a cool dry place, the troubles above referred to will disappear, without necessitating the discontinuance of the use of any of the recommended substitutes for wheat flour, or admixtures of wheat flours with other flours.

6. *The More Important Cereal Products.*—The following is a brief summary of the principal cereal products.

a. Wheat Flour.—Composed chiefly of the starch bearing parenchyma of the wheat kernel, with most of the gluten bearing tissue, and some epidermal tissue, including a few trichomes. The bran is excluded, being left on the bolting cloth.

b. Graham Flour.—So named after Dr. Sylvester Graham, is made from the entire wheat kernel. It includes, bran, middlings, and the white flour proper. It contains all of the tissues of the wheat grain—trichomes, parenchyma, epidermis, starch.

c. Wheat Middlings.—A substance separated from the other flour products during the milling (rolling) process, consisting largely of the hypodermal protein tissue, some bran, and some of the starch bearing parenchyma. Middlings proper is the unfinished product of the rolling process, minus the bran and break flours. It is the portion of the flour (or rather that portion which is finally to be added to the finished flour) richest in proteins and vitamines.

d. Rolled Wheat and Oats.—The whole grain cleaned, softened by steaming and passed between heavy rollers and afterwards dried. Some of the starch granules are partially dextrinized by the heat employed.

e. Flaked Corn.—The kernels of corn (yellow corn) steamed until soft, rolled out into thin flakes, heated until crisp and brittle. Starch granules are much distorted by the heating (steaming) process.

f. Shredded Wheat.—The whole wheat grains washed, softened by steaming and then forced through a perforated plate and formed into cakes or biscuits which are then baked. Starch granules more or less heat dextrinized.

g. Force.—Partially malted, cooked, and granulated wheat, barley, and other cereals, rendered hard by baking and roasting. Starch much modified by the heating process.

h. Cream of Wheat. Wheat Germs. Grits.—Composed largely of the germs of wheat, which are separated out in the milling process.

i. Puffed Rice, Wheat, and Corn.—The whole rice and wheat kernels are popped (by a patented process, the invention of Prof. A. P. Anderson) in closed retorts. The grain (a charge of about 5 pounds to each retort) is heated under pressure and upon suddenly releasing the pressure the starch granules are exploded, forming the puffed grain. Roasted to render it brittle. Rice puffs better than wheat. Corn is first ground and made into a paste, formed into pellets, dried, and then puffed by above process. The Chinese and Hindoos have puffed rice for many ages by a very simple process (drying the rice and popping in hot sand).

j. Bran.—A by-product in making white flour, consisting of the epidermal tissue (including most of the trichomes), much of the gluten bearing tissue and a small amount of the starch bearing tissue. Much used as cattle feed, chicken feed, and as a bulk-food in constipation; as an adulterant of coffee and of spices, etc. Roasted with syrup it forms a coffee substitute. May be adulterated with ground corn cobs, with chaff and screenings.

k. Rye.—Preparations from rye resemble similar preparations made from wheat. Rye flour is darker and moister than wheat flour. The larger simple starch granules measure from 40 to 65μ (30 to 50μ in wheat) and some of them show distinct fissured hili. There is no gluten in rye flour (try the hand gluten test).

The hand gluten test is made as follows. Weigh out a definite amount of flour, mix with enough water to make a kneadable dough, work this thoroughly between fingers, gradually wash out all of the starch in small stream of water, or in a dish of water. In a good quality of wheat flour there should be 30 per cent. moist gluten (by weight).

Wheat flours differ in bread making qualities. The soft wheat flours are preferred for bread making while the hard wheat flours are preferred for making sphaghetti, macaroni, and noodles.

It is known that there is considerable variation in the proportion of the larger to the smaller starch granules in different varieties of wheat and in the different grades of flour made from one and the same, as well as from different wheats. Breads made from flour in which the ratio of larger to smaller granules is comparatively high (1 : 3 to 1 : 5) are lighter, softer, and no doubt more easily digested. This starch granule ratio may be determined as follows.

DETERMINING THE STARCH GRANULE SIZE RATIO IN WHEAT FLOURS

The suspensions of the flour and the starch counts are made as already described. Two separate counts are made, one of the larger starch granules (all granules 15 (μ) microns and more in diameter) and one of the smaller starch granules (all granules less than 15 (μ) microns in diameter). The ratio between the number of larger and smaller starch granules shall be known as the starch granule ratio and it is recommended that this ratio be used in estimating the quality of wheat flours. A starch granule ratio of 1 : 3 to 1:4 is high; from 1 : 4 to 1 : 6 medium; and from 1 : 6 to 1 : 8 is low, and the quality of the flours made from wheat showing such ratios is correspondingly good or high grade, medium grade and poor or low grade. Flour made from wheat grown in the eastern United States gives the higher starch granule ratios (1:3 to 1:6) while flour made from wheat grown in the far West (California, for example), shows the lower ratios (1 : 6 to 1 : 8). Based upon the examination of many samples, the starch granule ratio for flours made from wheat grown in the middle West (Kansas, Iowa, Illinois, Nebraska) is approximately 1 : 5. It must be kept in mind, however, that the different processes employed by millers (sterilized, bleached, patent flours, break flours, etc.) also modify the ratio. The starch granule ratio bears no relationship to the differences in gluten and protein granule content of different wheats and of different wheat flours.

It may be stated that there are marked local geographic variations in the starch granule ratios. Also, the ratio varies in different varieties of wheat.

8. Canned Foods

1. *General.*—In the broader more comprehensive sense, canned food, includes all food substances put up in any hermetically sealed container and subjected to a heating process with a view to sterilizing and preserving such food until desired for consumption. The container may be a barrel, a cask, a large tin can (5 to 10 gallons), small tin cans, glass jars of all kinds and sizes, larger and smaller bottles, etc. The sealing may be by soldering, crimping, screw tops, friction caps, corks, rubber stoppers, paraffine, etc., etc. The sealing may be perfect, good, fair, bad, and wholly unsatisfactory.

2. *Special.*—It is in the micro-analysis of canned foods of all kinds that skill and experience are the essentials. A wide familiarity with the microscopical appearance of all kinds of vegetable as well

as animal tissues is essential, the details of which may not be gone into at this time.

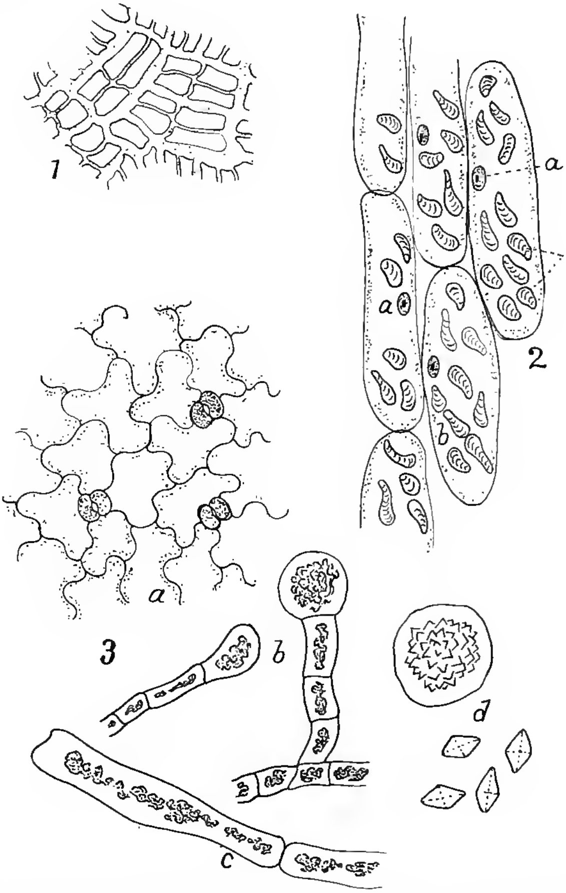

FIG. 60.—Diagnostic tissue elements. 1, the so-called "window cells" of the apple epidermis; 2, starch bearing pulp cells of the banana; 3, tissues of spinach; *a*, leaf epidermis; *b*, trichomes; *c*, pulp cells; *d*, crystals of calcium oxalate. Canned spinach is generally of poor quality, may be from overripe plants (abundant pollen), inadequately washed and may show sewage contamination and may be moldy.

3. *Ratings.*—The following maximum limit ratings are to be considered in connection with careful organoleptic tests, as has already been suggested.

Classes of canned Foods	Total bacteria (per cc. or Gm.)	Endospores (per cc. or Gm.)	Spores and Yeasts (per cc. or Gm.)	Mold (per cent. of fields)
(*a*) Meats.........	15 to 40,000,000	500,000	50 to 500,000	Few
(*b*) Vegetables.....	100,000,000	500,000	10,000,000	5 to 25 per cent.
(*c*) Mixed.........	50 to 80,000,000	500,000	1 to 5,000,000	5 to 15 per cent.

4. *Adulterations.*—Canned beef may contain horse meat, whale[1] meat, and other kinds and grades of meat cheaper than beef. Pork may contain beef and other cheaper meats. Other forms of adulterations have already been referred to.

9. Cereals. Gramineæ

1. *General.*—Under cereals are usually understood the ripened seeds of wheat (*Triticum vulgare*), rye (*Secale cereale*), barley (*Hordeum sativum*), oats (*Avena sativa*), rice (*Oryza sativa*), spelt (*Triticum spelta*), and millet (*Panicum miliaceum*). Corn (*Zea mays*), buckwheat (*Polygonum fagopyrum*), Kafir corn, and other seeds or grains rich in starch and used in pastry and bread making, are usually not included under the term cereal.

The seeds of the same cereal may differ considerably in size and form, when grown in different countries, different localities in the same country, and in different soils in the same locality. The same kind of grain may be large, small, soft, hard, full, shrunken or shriveled, bright color, dull color, etc. There are innumerable cultural varieties, each with special qualities known to specialists in various lines. Some of these special qualities appeal to the grower, some to the miller, others to the baker, to the consumer, etc.

2. *Special.*—The various cereals and other starchy food seeds, are quite easily recognized and identified by the characteristic starch granules, as may be seen from the illustration under starches. The flours and meals made therefrom also show more or less of the different seed tissues (epidermis, trichomes, parenchyma, other tissues) which are of interest to the microanalyst and with which the microanalyst must be thoroughly familiar.

3. *Ratings.*—The following ratings are intended as suggestions, rather than as actual standards.

Cereal Products	Bacteria (per gram)	Spores (per gram))	Mold (ergot and smut)
(*a*) Whole grain	Few	Few	Little
(*b*) Prepared grains	Few	Few	None
(*c*) Middlings	500,000	Few	Trace
(*d*) Bran	1,000,000	500,000	Some
(*e*) Flours	500,000 to 1,000,000	Trace	None
(*f*) Meals	500,000	Trace	Little

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[1] Whale meat was a very temporary food only and seems to have disappeared from the market.

4. *Adulterations.*—Trouble frequently arises over water and fire damaged cereals. Legal questions (damage claims) therewith require settlement. The final disposition and use of such cereals must be determined, usually by chemists, mycologists and micro-analysts. The souce of the cereal, or the variety, may be falsely stated. There may be undeclared or falsely declared admixtures or blends, etc. A fuller discussion of this very important matter is out of place in a work of limited scope. The desired or necessary information must be obtained in a reference library and through other channels of information.

10. Cheese

There is no microbiological standard for the various cheeses. The microscopical examination reveals little which might be of value in determining the quality of this class of food stuffs. Furthermore, only those having had extensive experience in the manufacture of cheese are in position to give opinions as to quality (odor, taste, consistency and color). In a general way the following will serve as a basis for rejecting cheeses.

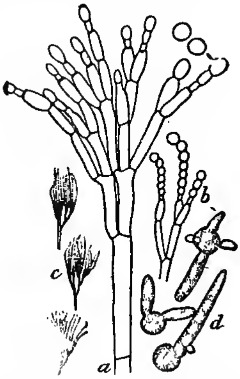

Fig. 61.—Penicillium of Camembert and Roquefort cheese. This mold grows at a very low temperature. It is closely similar to, if not identical, with *P. glaucum*.—(*Jordan after Thom.*)

1. A marked change in the usual consistency of the cheese. If a normally firm cheese becomes soft to almost liquid, it should be rejected without further examination.

2. A marked change in the usual odor of a cheese should arouse suspicion, especially if the odor becomes putrid, fecal, or otherwise excessively or unusually bad.

3. A marked change in color may point to harmful decomposition of the cheese.

4. Cheeses showing skippers or hoppers indicate carelessness in screening during the ripening period. Such cheeses are usually old and should be rejected.

In common with other products of decomposition, cheese is not a concentrated food in the true sense. That is, a pound of ripened cheese has less food value than is contained in the amount of milk required to make a pound of cheese, leaving out of consideration the possible harmful effects from the toxic substances which are believed to exist, in greater or lesser amounts, in all highly ripened cheeses. Poisoning from cheese (tyrotoxism) is not by any means uncommon. One difficulty in applying the organoleptic tests in examining certain cheeses (Limburger, Brie, Camembert, Roquefort, and others) lies in the fact that a putrid odor arising from the entrance of certain ptomaine formers, cannot be readily differentiated from the usual or normal cheese odor. It must also be kept in mind that cheeses of all kinds, are quite perishable, unless kept in a cool place, away from outside contamination, and that under favorable conditions the usual or ripening process goes on indefinitely, or, until the normal ripening changes are supplanted by secondary decompositions.

11. Cherries. Ripe, Dried, Canned, Preserved. *Prunus cerasus*

1. *General.*—There are over 200 cultural varieties of cherries; red and dark red, white; sour and sweet; large and small. The larger juicier, sweeter varieties are eaten raw; others are dried, canned, preserved, made into alcoholic beverages (Kirschwasser, Ratafia, Maraschino), and pickled or packed in brine. The Maraschino (Marascho) cherry is bleached, saturated with sugar and glucose and dyed red with a coal tar dye, for use with alcoholic drinks, soda fountain drinks, sundaes, etc.

2. *Special.*—The epidermal tissue consists of polygonal cells and resembles that of the plum. There are no trichomes. The pulp cells are large, typical in form, and contain little else than cell sap. The pits and seeds find no use in most countries. The seeds, when dry, may be eaten and are occasionally used in pastry and in confections. They have an aromatic flavor. Green cherries contain some starch. Ripe cherries contain no starch.

3. *Ratings.*—Rain split cherries (on the trees) immediately be come infected with mold. Dried cherries, cherry preserves, and sauces, may contain an excess of mold. Rain split and mold infected cherries are often canned. The acid of the fruit in its action on the tin may cause corrosion, and will also bleach the cherries more or less. The cans for cherries and other acid vegetables, should be lacquered on the inside. Coloring matter may be added to give the cherries a brighter hue.

Cherries are used in pies, sauces and puddings. The pits may or may not have been first removed. There are some fairly satisfactory cherry pitting machines on the market.

The American wild cherry (*Prunus serotina*) is eaten to some extent. The choke cherry (*Prunus virginiana*) is poisonous. Cherry eaters should make it a rule never to swallow the pits as they may cause trouble. The varieties of cherries best suited for canning are generally somewhat insipid.

12. Dried Foods

1. *General.*—The quality of dried foods depends upon the quality of such foods before drying, the care and attention given them during drying, and the care observed in preserving them after drying. Dried foods are doubly dangerous in some regards. For example, a toxic bacterial decomposition change may have been set up at the beginning of the drying process which change is partially inhibited and even completely checked as the drying advances, with the result that the finished article may appear quite normal and yet contain sufficient formed toxin to do serious harm.

2. *Special.*—The microscopical examination aided by the use of suitable differential stains (Broca's, Giemsa's, and others) will show the degree of decomposition which has taken place. In the usual stained smear preparation (Broca stain) the decomposed (bacterially) cells and cell-contents stain a deep blue, whereas, the undecomposed elements and plasmic substances stain a bright red to purplish red and pink.

3. *Rating.*—The quality and decomposition of these foods have already been referred to elsewhere. As a rule, dried animal food substances are more likely to show harmful bacterial decomposition than dried vegetable substances. Spores, yeasts and molds are more apt to appear in badly cured or dried vegetable substances, although mold may also be abundant in badly dried meats (hams, shoulders, bacon, etc). Dried mushrooms which give off a putrid, dissecting room odor, should be rejected without further examination. The microscopical examination will reveal abundant bacteria and foreign mold. The organoleptic tests are valuable adjuncts to the microscopical examination of dried foods.

Dried foods	Bacteria (per gram)	Spores (per gram)	Mold (per cent. of fields)
(*a*) Animal (exposed surface tissues)	5,000,000 to 80,000,000	Few	Trace
(*b*) Vegetable	40,000,000 to 100,000,000	5,000,000 to 10,000,000	5 to 10

Sun dried vegetable substances may contain mites, plant lice, and the excreta of mites and insects. Dried figs frequently contain abundant bacteria, spores, and mold. Dried shredded coco nut meat (*copra*) may be very rancid without revealing bacterial or mold decomposition (apparently a molecular decomposition) Dried apricots frequently contain abundant mites, dead and living.

13. Fermented Food Products

These have been referred to elsewhere. There is no recognized standard of purity or freedom from foreign organic (living) contamination. The organoleptic tests are the principal guides to the quality of this class of foods. With few exceptions (sour milk, Sauerkraut) fermented foods are not used as regular bulk foods, as are meat, potatoes, bread, etc.

14. Fish, Fresh, Preserved, and Canned

The organoleptic tests are very important in determining the quality of this class of food, as has already been set forth elsewhere. The following should be kept in mind.

1. A pronounced or exaggerated fish odor indicates incipient decomposition. Examine carefully microscopically.

2. A very faint or weak fish odor indicates a further advance in decomposition.

3. All "off odors" or flavors are significant, as they usually indicate advanced decomposition. Unusual odors may be due to some added flavor, to bleaching, to extra processing, to heavy spicing etc., for the purpose of masking any advanced decomposition which was known to exist.

4. An ammonia odor may occasionally be noted in canned fish. This indicates decomposition by ammonia forming bacilli (small, irregular in form). The ammonia odor may even be powerful, equal to that of ammonia water.

Fresh fish should have a normal fish odor, there should be no mold, and bacteria should not exceed 15,000,000 to 25,000,000 per gram.

Smoked, salted, and kippered fish (both salted and smoked) should be of good color, free from pink rot and mold, and should not contain more than 40,000,000 bacteria per gram.

Canned fish should not be discolored, mottled, darkened or abnormally pale. Gutting should be well done. The meat should be soft yet firm, not pulpy and mushy. The outside of the fish should not feel smeary or slimy to the touch. Bacteria should not be in excess of 80,000,000 per gram of the meat. Canned fish may contain as high as 20,000,000,000 bacteria per gram.

All canned fish requires careful examination to determine its fitness for human consumption. Imported salted anchovies have appeared upon the market which were in an advanced state of decomposition, giving off a horrible odor, the meat red in color (pink rot) and falling away from the bones, and yet the importers contested an order for its destruction. Fish in an advanced state of decomposition has been canned and over-processed in order to kill the organisms of decomposition, and analysts have been found who reported such fish wholesome and free from bacteria simply because "the plating tests gave negative results."

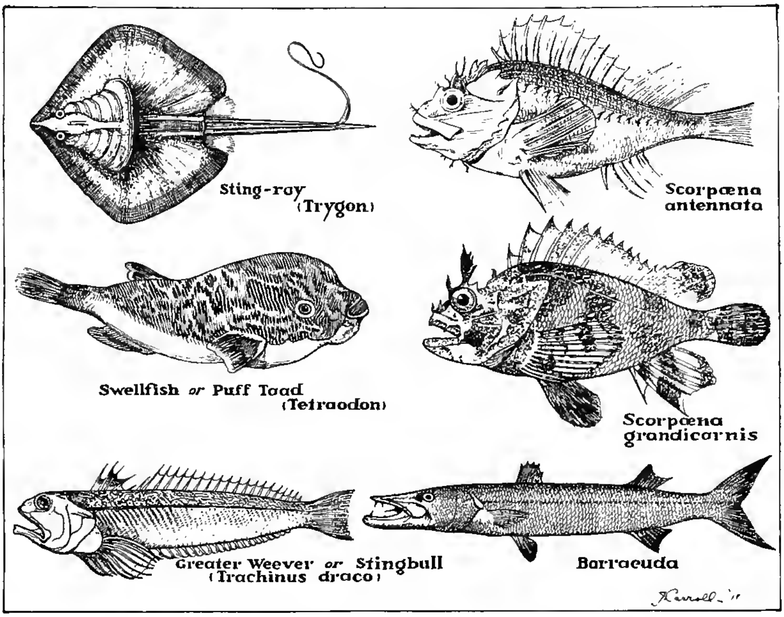

FIG. 62.—Types of poisonous fish.—(*Stitt.*)

The pink rot of pickled, kippered and salted sardines, herring and other fish, has received considerable attention on the part of the trade and recently also on the part of food bacteriologists. Canners have declared that the red color which is especially highly developed in the muscle fiber along the spinal column, is due to the salting and pickling. This has been proven to be wrong. The change is due to decomposition initiated by a group of small bacilli which thrive in meats, especially fish, entirely saturated and covered with salt. The bacterial development appears to be retarded by the salt but cannot be entirely inhibited, no matter how much salt may be used. The bacteria appear to be largely of filth origin, traceable to dirty hands, dirty tables and containers, filthy trimming knives, etc.

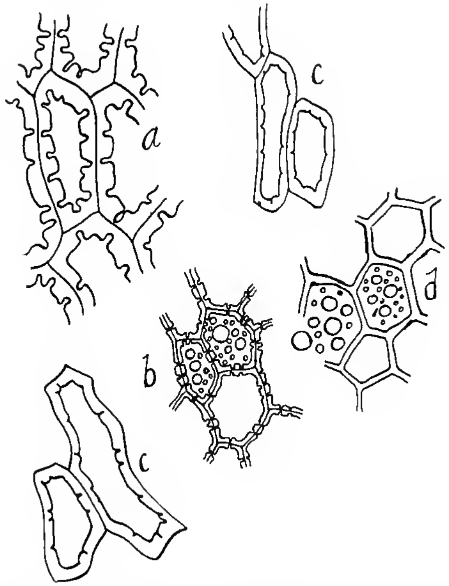

FIG. 63.—Cayenne pepper tissue. *a*, *b*, and *c*, pericarp tissues; *d*, pericarp parenchyma bearing numerous red oil globules. May contain an excess of calyx tissue, leaf tissue, and may be adulterated with corn meal and may be moldy.

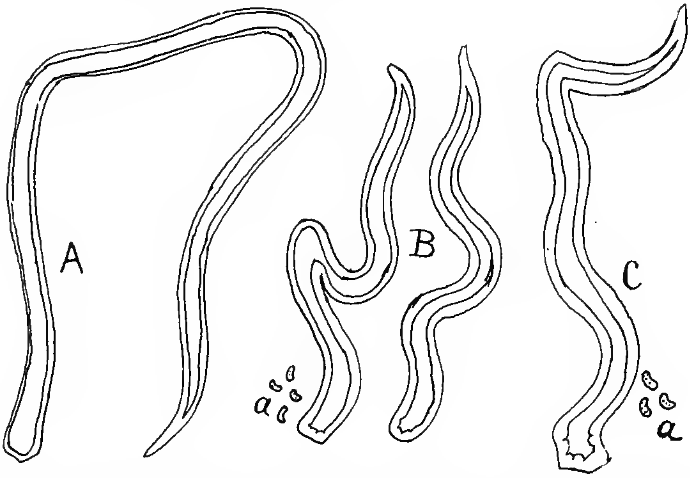

FIG. 64.—Diagnostic trichomes. A, strawberry; B, raspberry, seed (*a*); C, loganberry, seeds (*a*). The seeds of the raspberry measure 2 mm. in long diameter, whereas those of the loganberry measure 3 mm.

Toxic roe (of the shad and of other fish) has been mentioned. The meat of some fish (mostly tropical varieties) is highly poisonous. The bite of some fish is poisonous and others have poisonous spines. The spines of the sea urchin may give rise to serious injuries. In passing it may also be mentioned that the jelly-fish is poisonous, likewise some of the sea anemones. In some seas the men must be cautioned against swimming in deeper waters because of sharks. In foreign and unknown seas and other fish bearing waters, no fish taken from such waters should be eaten until first approved by the dietitian. The inhabitants are usually well informed as to edible and inedible and poisonous varieties of fish, and it is well to be guided by their cautions and suggestions.

15. Fruits, Ripe, Dried, Canned, Fruit Juices

1. *General.*—Clean, ripe wholesome fruit contains bacteria and other organisms, in negligible quantities only. A clean ripe apple contains practically no bacteria. On the other hand, a well cleaned beet, raddish, turnip, or other underground vegetable, may contain numerous bacteria. A washed unpeeled potato may contain many bacteria, whereas a washed peeled potato contains few bacteria. Occasionally a fruit, tuber, or fleshy root may be found which appears sound on the outside, and yet harbors many millions and billions of bacteria (per gram) in a decomposed interior, the bacteria (anaerobes) having gained access *via* minute breaks in the epidermis, the breathing pores, and the conducting tissues. This is a rare occurrence however.

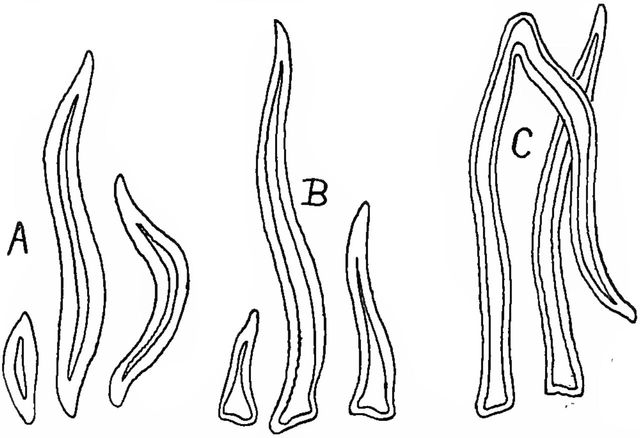

FIG. 65.—Diagnostic trichomes of fleshy fruits. A, peach trichomes; B, apricot trichomes; C, quince trichomes.

2. *Special.*—The whole fruits are of course readily identified. The pulped fruits are readily identified microscopically, assisted by the organoleptic tests.

The following are the more important diagnostic tissue elements of the principal fruits and seeds.

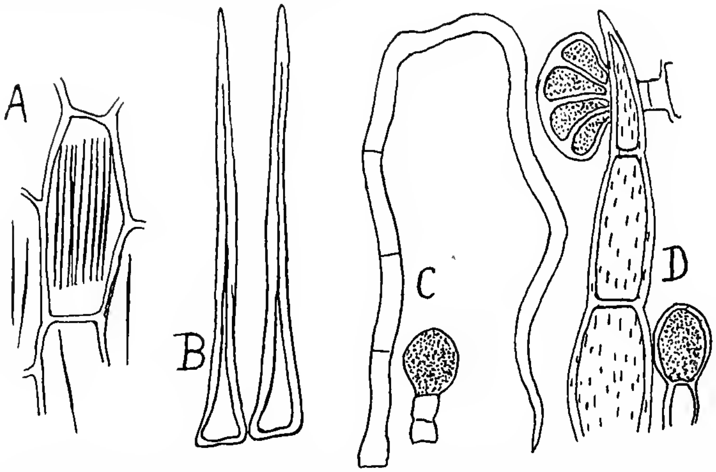

Fig. 66.—Diagnostic tissue elements. A, a parenchyma cell of the pineapple containing a cluster of acicular crystals of calcium oxalate (raphide); B, two trichomes of the tomato seed; C, simple and glandular trichome of the sage leaf; D, simple and glandular trichomes of marjoram. Marjoram is generally adulterated.

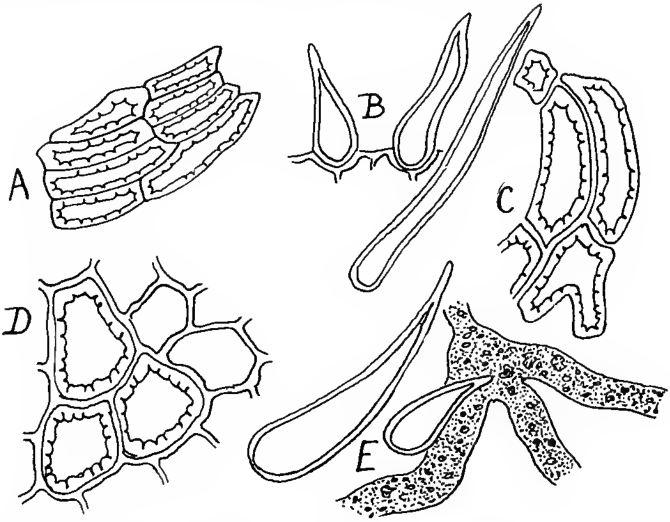

Fig. 67.—Diagnostic fruit tissues. A, a group of sclerenchymatous cells of the currant; B, trichomes of the gooseberry. In addition to these single celled trichomes the goose berry has large stiff prickles which are multicellular. C, a group of sclerenchymatous cells from the endocarp of the blueberry *Vacinium myrtillus*); D, three sclerenchyma cells from the mesocarp of the huckleberry (*Gaylussacia resinosa*); E, trichomes and a branching laticiferous duct of the fig (*Ficus carica*).

(*a*) *Almond.*—No starch, thin-walled sclerenchyma cells derived from the testa or seed coat. Fat globules and protein granules are abundant. Endosperm cells are thin-walled, colorless (Fig. 69).

(*b*) *Apple.*—See (2), Chapter IX. (Fig. 60).

(*c*) *Apricot.*—See (3), Chapter IX.

(*d*) *Banana.*—See (4), Chapter IX.

(*e*) *Capsicum.*—Epidermal cells of seeds with thick convolute walls. Red oil globules. No starch. No epidermal trichomes. Epidermal tissue of pericarp and of calyx may be present.

(*f*) *Cherry.*—Window cells not well marked, large (35μ to 100μ). No trichomes. Large pulp cells. Coloring matter.

(*g*) *Chestnut.*—Trichomes (simple) variable in length. Abundant irregular, simple, pear shaped starch granules, with wart-like excrescences and eccentric hili; there are some compound starch granules.

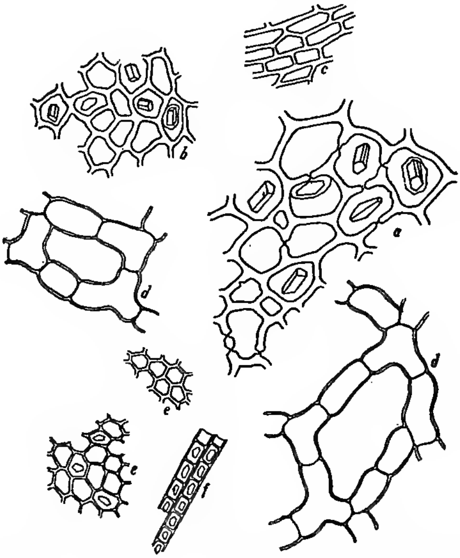

FIG. 68.—The orange (*Aurantium*). *a*, *b*, *c*, parenchyma cells from the outer layer of the rind bearing crystals; *od*, spongy tissue cells from the inner rind pulp; epidermal cells, vertical view; *f*, crystal bearing fibers.

(*h*) Chillies. (See capsicum).

(*i*) Coco Nut. Shredded coco nut pulp. Elongated parenchyma cells. Abundant oil globules. No starch. No coloring matter.

(*j*) Blackberry. No trichomes. Coloring matter. Large pulp cells. (Mold may be abundant.)

(*k*) Blueberry. Characteristic sclerenchymatous elements of the mesocarp. Dark violet color.

(*l*) Currant. Groups of elongated sclerenchymatous elements. Coloring matter.

(*m*) Date. Sclerenchymatous cells. No starch. No trichomes.

(*n*) Fig. Large lactiferous ducts. No starch. Single-celled rather short trichomes. Sclerenchyma cells of the seeds. (Spores and mold may be abundant.)

(*o*) Grapes. Acicular crystals. Large pulp cells. Seed sclerenchyma.

(*p*) Quince. Trichomes similar to those of the peach. Groups of sclerenchyma cells similar to those of pear. Endocarpal trichomes like those of apple. Window cells (10μ to 25μ) like those of pear.

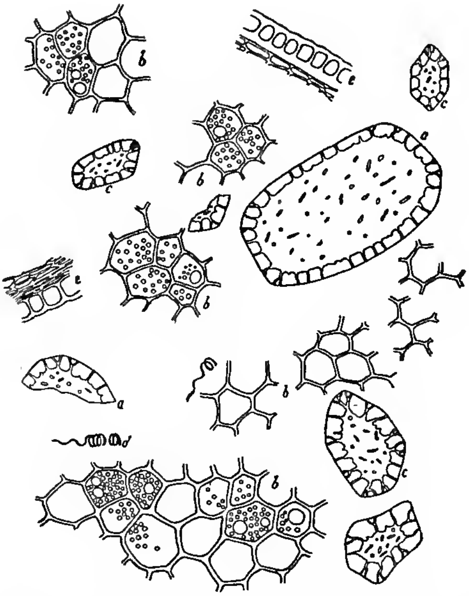

FIG. 69.—The almond (*Amygdala dulcis*). *a*, the thin-walled sclerenchyma cells of the seed coat; *b*, endosperm cells bearing proteid granules; *d*, spiral ducts; *e*, cells from the inner layer of the seed coat, lateral view. Almonds may be adulterated with the seed of other drupaceous fruits, as of the peach, the plum, the apricot and others. The bitter almond is recognized by its bitter taste and it is poisonous.

(*q*) Raspberry. Simple, single-celled trichomes. Seeds are flattened, kidney-shaped and measure 2 mm. in length. In the Loganberry the trichomes are longer and the seeds measure 3 mm. in length. The Loganberry (named after judge Logan) is an accidental cross between the blackberry and raspberry.

(*r*) Tomato. The fruit of *Lycopersicum esculentum*.

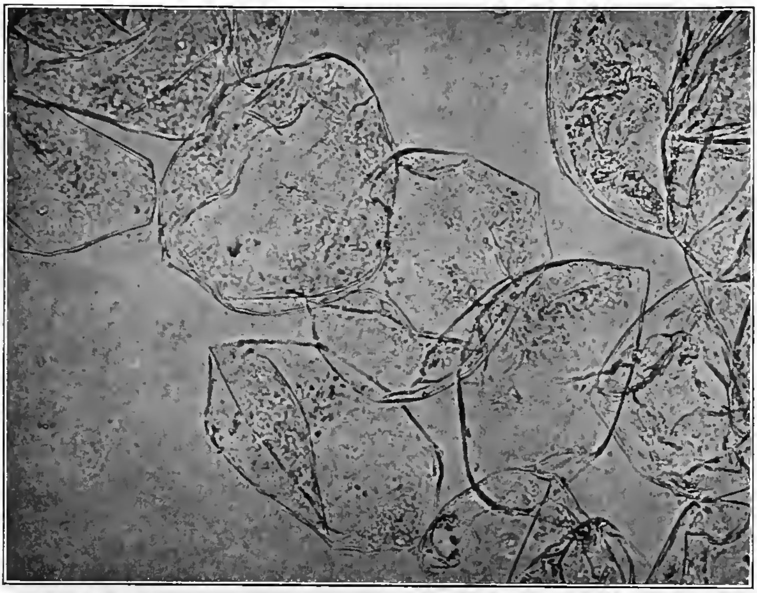

FIG. 70.—Tomato pulp cells in normal catsup. The cells are large, thin-walled, containing granular particles. The coloring matter of the tomato frequently appears as deep scarlet-red crystalline particles usually arranged in groups within the cell.—(*Howard, Yearbook U. S. Dept. of Agriculture*, 1911.)

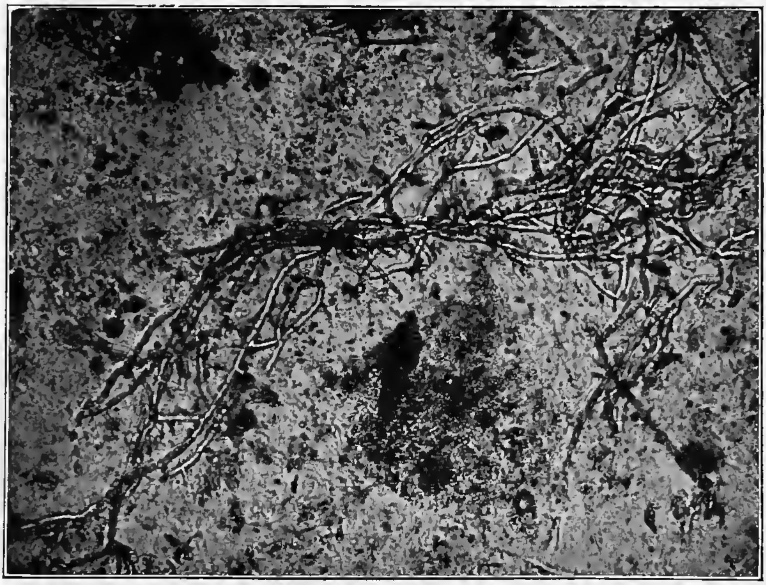

FIG. 71.—Cluster of mold hyphæ in granular (decomposed) tomato pulp. This type of mold is traceable to field-rotted tomatoes. The finding of hyphæ of this type in tomato catsup indicates the use of rotted tomatoes, therefore, indicates inadequate culling at the factory.—(*Howard, Yearbook U. S. Dept. of Agriculture*, 1911.)

Within recent years the tomato production has assumed colossal proportions in the United States, for which reason this fruit must be given special mention.

1. *General.*—Green tomatoes contain starch (granules, simple pear-shaped, distinct lamellation, eccentric hili); two forms of coloring matter (rusty brown irregular particles, and deep purplish red elongated crystals) are found; sphærocytes, especially the nucleo-sphærocytes, occur in abundance in proportion to the ripening changes in the fruit.

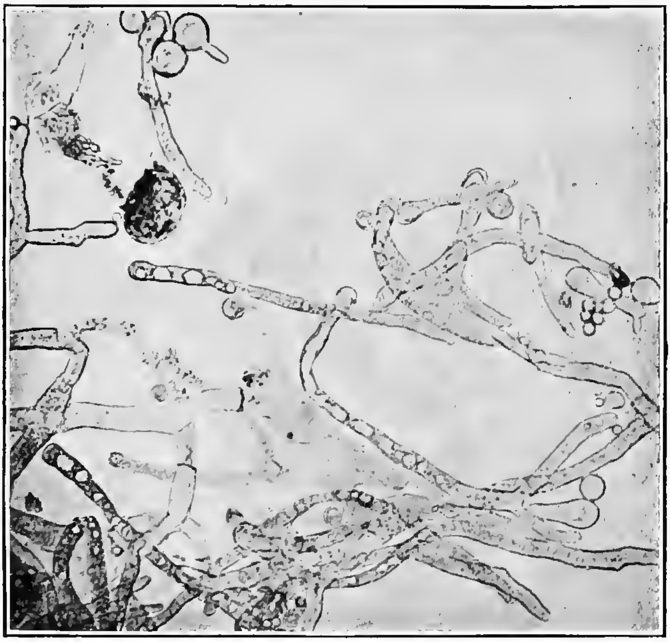

FIG. 72.—Type of mold development in the tomato pulp during and after the processing. According to tests made by B. J. Howard of the Bureau of Chemistry, mold will develop in tomato catsup containing 0.1 per cent. sodium benzoate. Compare the hyphæ with those shown in Fig. 11. They are much larger in transverse diameter and the walls of the cells are much thinner.—(*Bitting, Bull.* 119, *Bureau of Chemistry, U. S. Dept. of Agriculture.*)

Tomatoes grown in tropical and sub-tropical countries should be examined as to possible carriers of infections. In cholera countries, for cholera; in general for typhoid infection; in tropical countries for amebic dysentery; etc. Various forms of Ameba, Paramecia, and Ciliata have been found in tomatoes from Mexico and the West Indies. The parasitic *Nematospora lycopersici* was found in tomatoes from Cuba.

2. *Special.*—Epidermal cells, tapetal, polygonal, without special marks. Parenchyma cells, large, thin-walled, collapsed, broken. Tomato catsup and tomato sauce and paste consist of mechanically disintegrated parenchyma cells and of organic cell contents (plasmic substances, coloring particles), etc. Occasional clusters of seed trichomes and other seed elements (oil globules, epidermal cells and endodermal cells) are found. Note the tissue elements belonging to spices which are added. There may be added oil, as in pastes. Starch may be added to catsups, sauces and pastes.

3. *Ratings.*

Tomato Products	Bacteria (per cc.)	Spores (per cc.)	Molds (per cent. of fields)
(*a*) Pastes	25,000,000 to 500,000,000	2,000,000 to 10,000,000	20 to 50
(*b*) Sauces	10,000,000 to 200,000,000	500,000 to 3,000,000	15 to 30
(*c*) Catsups	10,000,000 to 100,000,000	500,000 to 2,000,000	10 to 25
(*d*) Purees	3,000,000 to 75,000,000	1,000,000 to 2,000,000	8 to 25
(*e*) Tomatoes. (with puree)	1,000,000 to 15,000,000	500,000 to 1,000,000	2 to 10
(*f*) Trimmings	3,000,000 to 50,000,000	1,000,000 to 2,000,000	5 to 25
(*g*) Dried[1]	100,000,000	500,000	5 to 8

4. *Adulterants.*—Starch (wheat flour, corn starch, rice starch) may be added to pastes, catsups, and purees. Other fruit pulps are rarely added (squash, pumpkin). Should not contain benzoic acid (benzoates), but, if used, should not exceed 0.10 per cent. (*a*) should generally not be used for human consumption, and (*f*) only when derived from ripe, wholesome tomatoes. Organoleptic tests are useful, but should be interpreted with caution. Fats and oils are occasionally added to tomato products, especially to the pastes and catsups to render them more smooth. The more common spices used in catsups are capsicum, cloves, pepper, capsicum extract, onions, garlic, with salt, vinegar and sugar. The garlic and onion odor must not be confused with decomposition odors.

The following are the ratings of the more common canned fruit products, exclusive of tomato products.

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[1] As prepared experimentally by the Bureau of Chemistry; the University of California; and for market by reputable firms.

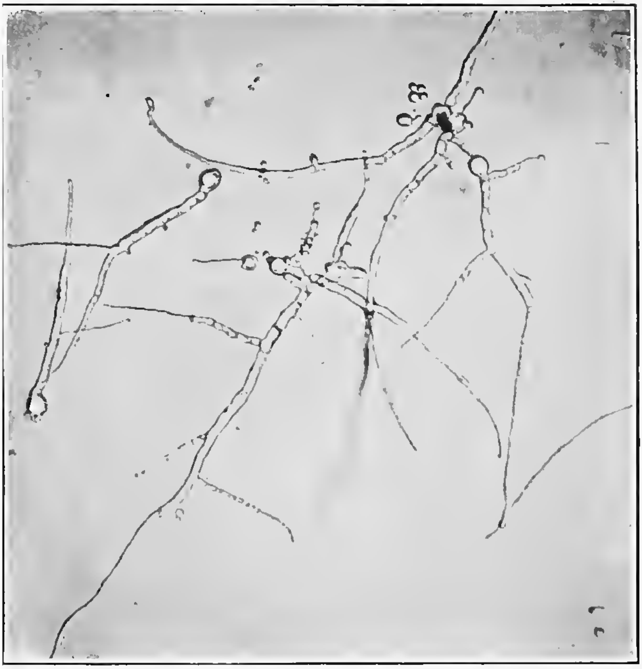

FIG. 73.—Various stages in the germination of spores in catsups. Note transverse septation and branching of the hyphæ. Germinating spores may be traceable to the tomato from the field or they may be from spoiling factory pulp.—(*Bitting, Bull.* 119, *Bureau of Chemistry, U. S. Dept. of Agriculture.*)

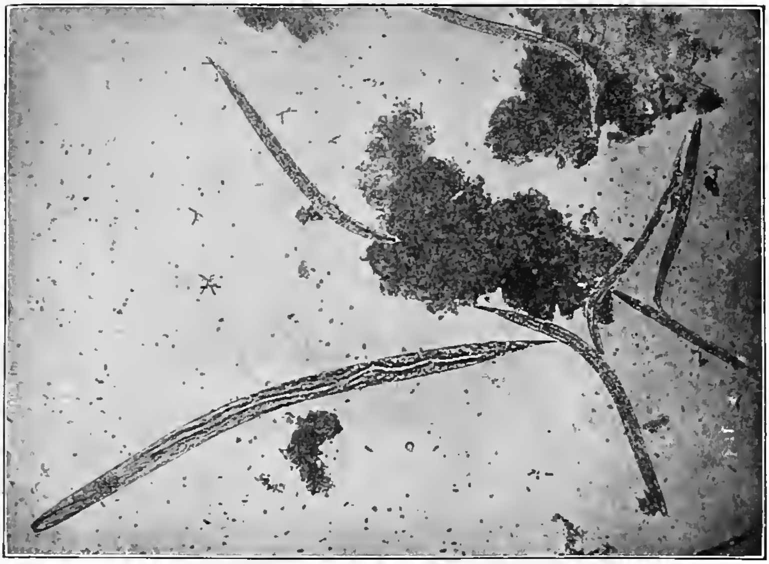

FIG. 74.—Vinegar eels from decomposed blackberry pulp. The small particles scattered through the field are yeast cells. Bacteria were also present but they do not show in the illustration.—(*Howard, Yearbook U. S. Dept. of Agriculture,* 1911.)

Fruit Product	Number per cc. or per gram			
	Bacteria	Yeasts	Spores	Mold (per cent. of fields)
Apple butter	500,000 to 5,000,000	5,000,000 to 15,000,000	Few	Few
Berries	5,000,000 to 15,000,000	10,000,000	2,000,000	10 to 15
Cider	10,000,000	15,000,000	Few	Few
Fruits	15,000,000 to 25,000,000	Few to 15,000,000	2,000,000	Few to 10
Jams	5,000,000 to 15,000,000	5,000,000 to 25,000,000	2,000,000	8 to 12
Jellies	10,000,000	5,000,000	Few	Few
Marmalade (orange)	Few	Few	Few	Few
Pickles	5,000,000	10,000,000	Few	Few
Preserves	10,000,000 to 30,000,000	25,000,000	2,000,000	10 to 12

16. Gelatine. Glue Rating

The microscopical examination of gelatine and glues has suggested a comparatively simple and exceedingly reliable method for determining the quality and purity of gelatine. The usual chemical and physical tests which are applied to the products do not give evidence of the presence of bacterial or mold contamination or of other organic contamination. Some of the chemical tests do give indirect or presumptive evidence of bacterial and similar contaminations and therefore have a corroborative significance.

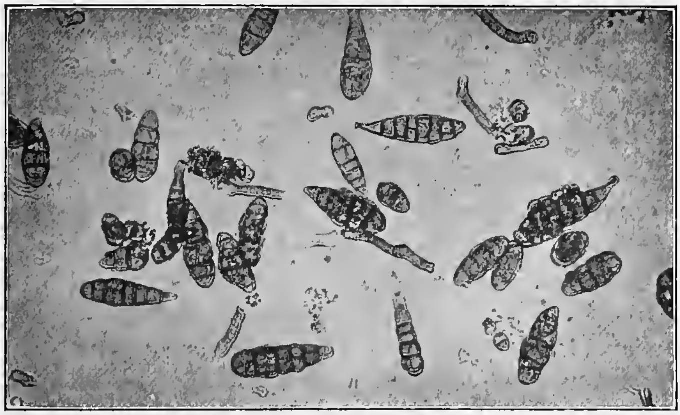

FIG. 75.—Spores and hyphal fragments from decaying sweet pepper. "Dry rot" fungus.—(*Howard, Yearbook U. S. Dept. of Agriculture*, 1911.)

1. *General.*—An absolutely pure gelatine does not exist, at least none has come to notice. All gelatines contain some bacteria and a variable number of insoluble (in hot water) organic particles. The quality of gelatine decreases in direct proportion to the increase in bacteria, in mold, and in insoluble organic matter. Of these contaminants, the bacterial and organic particles are the most constant and most diagnostic. Mold contamination proved to be quite variable. Certain gelatines which show a comparatively low bacterial count may nevertheless run very high in mold, while others which show a high bacterial count may run low in mold. The variation in bacterial contamination and in the amount of insoluble organic matter present is indicated in the table.

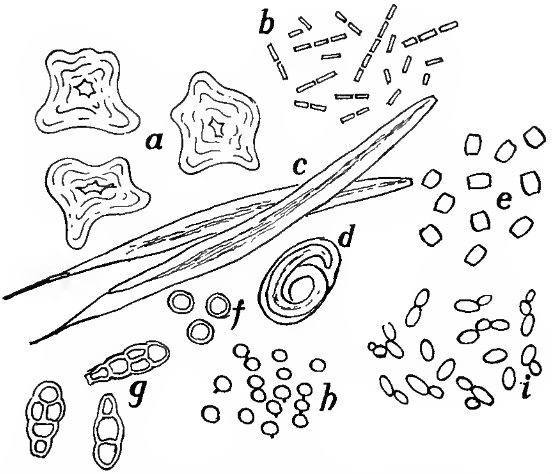

FIG. 76.—Substances frequently found in tomato catsup. *a*, Heat dextrinized corn starch. Starch is frequently used as a filler or stiffening agent. *b*, bacteria which frequently appear in great numbers. *c*, Vinegar eels derived from cider or wine vinegar. Soil nematodes may also be found, indicating gross soilc ontamination and inadequate washing at the cannery. *d*, Nematode larvæ derived from the soil. *e*, *f*, *g*, *h*, Spore types frequently met with in catsups. *i*, Yeast cells.

The color of the commercial gelatines is quite variable, ranging from nearly colorless and transparent to rather dark amber-brown. While the depth of the amber coloration is generally proportional to the age of the article, this is not always the case, as some of the powdered or granulated gelatines are made from old bleached sheet gelatine. There is apparently no close relationship between the color of gelatine and the degree of contamination, nor does contamination increase materially with age, provided of course, the gelatine is kept in a dry, cool place. The contamination of gelatine usually takes place prior to and during manufacture.

2. *Special.*—There is a fairly uniform relationship between the turbidity of gelatine solutions and the degree of contamination. It would, in fact, be possible to rate the quality of gelatines fairly accurately by this character alone. It is, however, an easy matter to confuse color and turbidity for which reason the turbidity test alone is not conclusive.

The examination of commercial gelatines and glues showed that the gradation from comparatively pure, through less and less pure gelatine, to commercial glue, was quite uniform and this suggested the glue rating for gelatine. The laity and dealers have long arbitrarily rated gelatines in terms of glue, based wholly upon the odor test. It is generally known that a good gelatine has no glue odor whereas many of the market gelatines have a very pronounced, glue odor, which led to the popular notion that glue had been added. This is not actually the case, rather the gelatines having the glue odor are impure and are in part made from the material of which the cheaper grades of commercial glue are made. The following table shows the contamination in different market gelatines and the gradation from gelatine to glue. The glue percentages are somewhat roughly approximated to avoid the appearance of pedantry. The results are, however, sufficiently accurate for practical purposes. The mold count is omitted for reasons already given.

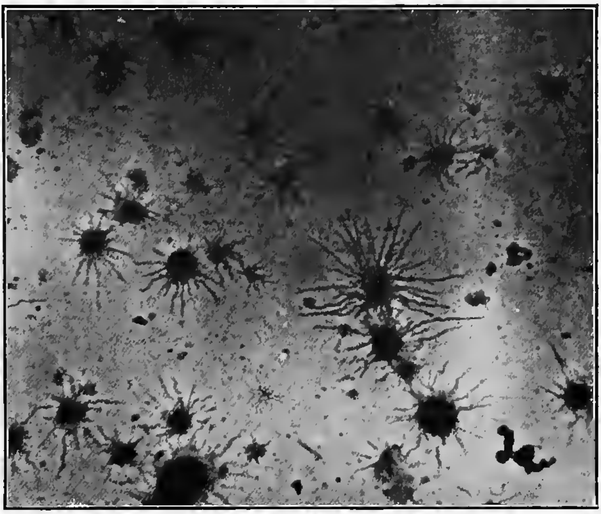

FIG. 77.—Mold colonies in gelatin seen under the lower power of the microscope (× 80). This mold developed in the gelatin after it was spread on the screen to dry. This gelatin also contained numerous bacteria. Gelatin thus infected is not suitable for bacteriological purpose neither is it suitable for use as food.

No. of Sample	Insoluble organic particles per gram (a)[1]	Total bacteria per gram (b)[1]	Glue per cent. $\frac{(a+b)}{2}$	Grades
1	Few[2]	18,000,000	0.3	(Slightly below grade A.)
2	Few	30,000,000	0.5	
3	Few	80,000,000	1.5	Grade B.
4	Few	112,000,000	2.0	
5	300,000	160,000,000	3.0	
6	500,000	265,000,000	5.0	
7	500,000	420,000,000	8.5	Grade C.
8	1,250,000	390,000,000	10.0	
9	1,000,000	640,000,000	10.5	
10	3,750,000	640,000,000	14.0	
11	4,000,000	815,000,000	18.0	
12	5,000,000	920,000,000	19.0	
13	15,000,000	1,340,000,000	33.0	(Below grade C.)
14	40,000,000	2,000,000,000	65.0	(Below grade C.)
15	97,000,000	2,500,000,000	100.0	Commercial glues.
16	100,000,000	2,650,000,000		
17	108,000,000	2,900,000,000		

3. *Ratings.*—The glue rating is obtained by dividing the sum of the percentages of inorganic particles and of total bacteria, as compared with glue, by two. For purposes of illustration we will let *glue-o* represent the total insoluble organic particles in average commercial glue (100,000,000 per gram) and *glue-b* the average total bacteria in commercial glue (2,500,000,000 per gram) and *gel-o* and *gel-b* the corresponding contamination in the gelatine under consideration, we then have:

$$\frac{\left(\frac{\text{gel-o}}{\text{glue-o}}\right) \times \left(\frac{100\%}{1}\right) + \left(\frac{\text{gel-b}}{\text{glue-b}}\right) \times \left(\frac{100\%}{1}\right)}{2} = \text{Glue percentage.}$$

To explain the above formula, let us suppose that a given gelatine contains a total of 2,000,000 insoluble organic particles per gram and a total of 350,000,000 bacteria per gram, as determined by means of the hemacytometer. Applying the formula we would have:

$$\frac{\left(\frac{2{,}000{,}000}{100{,}000{,}000}\right) \times \left(\frac{100\%}{1}\right) + \left(\frac{350{,}000}{2{,}500{,}000}\right) \times \left(\frac{100\%}{1}\right)}{2} = 8 \text{ per cent. of glue.}$$

In case the gelatine contains only a few or practically no insoluble organic particles, with a total of 350,000,000 bacteria, which is within the possible, the glue percentage would be:

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[1] (*a*) and (*b*) are to be figured on the basis of 100 per cent. each, deduced from the numbers for glue.

[2] Few means 50,000, or less, per gram.

$$\frac{\left(\frac{0}{100,000,000}\right)\times\left(\frac{100\%}{1}\right)+\left(\frac{350,000,000}{2,500,000,000}\right)\times\left(\frac{100\%}{1}\right)}{2} = 7 \text{ per cent. glue.}$$

Since gelatines have three distinctive uses, namely in medical practice, as a food for man and for bacteriological work, and a purely technical use, it is recommended that they be divided into three grades as follows:

Grade A.—Intended for medicinal use (hypodermic and intravenous injection).

(*a*) Must be entirely free from tetanus bacilli and other pathogenic and toxigenic micro-organisms.

(*b*) Should contain practically no insoluble organic particles and must be entirely free from insoluble solids of all kinds.

(*c*) Should not contain over 5,000,000 micro-organisms per gram. (See also (*a*)).

(*d*) Should contain practically no mold.

(*e*) Must be free from arsenic. (See biologic test for arsenic.)

(*f*) Should be free from glue odor.

(*g*) A 10 per cent. aqueous solution, or hydrogel, should be clear and entirely free from turbidity.

It is possible to manufacture gelatines complying with the above requirements, provided great care is observed. If it is possible to prepare a gelatine which is entirely free from organisms, then the absence of all organisms should be insisted on for grade A gelatines. The necessity of a high grade gelatine for medicinal use cannot be too strongly emphasized. Within recent years gelatines have been highly recommended for the purpose of increasing the coagulability of the blood. Should insoluble organic particles be injected into the blood circulation they might serve as centers for starting a blood clot which might cause death. Bacteria, even though harmless, should not be thrown into the circulation nor into the hypodermal tissues, excepting in the form of the standardized and definitely known bacterins.

Grade B.—Intended for human consumption and for bacteriological work, and for human use not mentioned under grade A.

(*a*) and (*e*) as for grade A.

(*b*) Should not contain more than 1,000,000 insoluble organic particles per gram.

(*c*) Should not contain more than 200,000,000 bacteria per gram.

(*d*) Should not contain more than 50,000 mold hyphæ or hyphal clusters per gram.

(*e*) Glue odor should not be more than faint or indistinct and there should be no mucus odor.

(*f*) A 10 per cent. solution, or hydrogel, should be only slightly turbid.

Grade C.—Intended for technical use only.

(*a*) As for grade A.

(*b*) Should not contain more than 10,000,000 insoluble organic particles per gram.

(*c*) Should not contain over 800,000,000 bacteria per gram.

(*d*) Should not contain more than 2,500,000 mold hyphæ per gram.

(*e*) Should not contain more than a trace of arsenic.

(*f*) Glue odor should not be more than distinct.

(*g*) A ten per cent. solution, or hydrogel, should not be more than distinctly turbid.

The following average quality standard is given for glue and upon which the gelatine glue rating is based.

(*a*) Presence or absence of tetanus or other pathogenic or toxigenic organisms is not determined.

(*b*) Contains about 100,000,000 insoluble organic particles per gram and about 25,000,000 fat globules per gram. (Fat globules are objectionable in glue because they reduce the adhesive and cohesive property of the glue.)

(*c*) Contains about 2,500,000,000 bacteria per gram.

(*d*) Generally contains more than 2,500,000 mold fragments per gram.

(*e*) Presence of arsenic and other minerals is not determined.

(*f*) Glue odor very marked, characteristic.

(*g*) A 10 per cent. solution, or hydrogel, is of a dull brownish amber color and highly turbid and quite opaque and gelatinizes poorly.

From the above it will be seen that the gelatine of grade A contains no glue, grade B may contain from 4 to 5 per cent. glue, and grade C should not contain more than 25 per cent. glue.

The mold contamination of gelatines is very variable. Some of the sheet gelatines show as many as fifty colonies in one field of the compound microscope (low power, about 90 diameters). Gelatines of grade A should contain no mold. Gelatines of grade B should not contain more than one colony per field of the low power of the microscope, or not to exceed 1,000,000 hyphal fragments per gram. No mold limit is proposed for gelatine of grade C or for glue.

Some of the commercial gelatine is made from hides which have been treated with arsenic as a preservative. It therefore becomes desirable to test gelatines for this substance. The following biological test is recommended.

Biological Test for Arsenic.—Into a clean sterile standard test tube place about four grams of dry bread crumbs, heat slowly over a Bunsen flame until bottom crumbs begin to brown and pour enough of the hot 10 per cent. gelatine solution (to be tested for arsenic) into the tube to moisten the crumbs throughout. Prepare three tubes in this manner. Plug the tubes with cotton and sterilize at 100°C. for 30 minutes. As soon as tubes are cool, inoculate them with the spores and mycelia of *Penicillium brevicaule*, replace cotton plugs and incubate at 37°C. If arsenic is present, a garlic-like odor will develop in he tubes, in from 12 to 48 hours. The vital incubator may be used in making this test.

This test is very delicate and reliable. A similar odor is developed in the presence of selenium and tellurium. Stock cultures of the mold *P. brevicaule* may be kept in the laboratory on bread in a moist chamber. Pieces of bread well covered by the mold may be allowed to dry and kept in a dry glass jar. The spores will remain viable for many months.

17. Meats

Meat contaminations and the organoleptic meat tests have already been mentioned. The following bacterial limits will be of value to analysts.

Kinds	Bacteria (per gram)	Mold
Fresh. (Exposed layers to depth of 5mm.)	500,000	None
Cold storage " " " " " "	80,000,000	Trace
Sausages	100,000,000	None
Dried, smoked. (Exposed layers to depth of 5mm.)	75,000,000	Some
Potted, pastes	200,000,000	Some
Minced	50,000,000	Some
Meat extracts	100,000,000	Trace

Considerable attention has recently been drawn to canned (usually put up in small glass jars) sliced beef, pork, and tongue (usually salted and smoked). Packers have from the first refused to guarantee this class of food for more than 90 days, realizing that marked decomposition changes are apt to be noted after this period. A careful microscopical examination of numerous samples of sliced meats has revealed the following conditions. (Fig. 40).

1. All salted and smoked meats contain an enormous number of micro-organisms upon the exterior. The micro-organisms are mostly quiescent (multiply only slightly) in this position, though most of them are viable (as evidenced by cultural methods and by the use of the Broca stain).

2. The slicing knife has the effect of distributing these micro-organisms over both surfaces of each slice.

3. The interior of the meat being non-sterilized by the smoking process and at most only partially sterile due to the salt, permits the development of the viable organisms which have been distributed by the slicing knife.

4. The more rapid multiplication of the micro-organisms is prevented by the reduced moisture, the trace of creosote and the salt and other preservatives which may be present.

5. The principal contaminating organisms are comparatively large coccus and diplococcus forms (smeary rot), and rather small bacillus forms (iridescent rot).

6. The decompositions referred to in (5) produce more or less marked changes in odor, but there is not the odor of putridity. The most distinctive taste (tactile) sensation is an acridity in the throat, on eating such meats.

7. The fat of pork is attacked by the coccus and diplococcus forms, resulting in a chemical change, the palmitic acid being converted into oleic acid, rendering the lard liquid. There is no rancidity developed by these organisms.

8. The rate of decomposition depends upon the temperature, the amount of moisture present, to a lesser degree also upon the amount of original contamination, and the care observed in packing.

9. Canning sliced meats should be abandoned, for the reasons set forth. Sliced meats should be eaten at once.

10. Tentatively, all sliced canned meats should be rejected if,

(*a*) The color and odor are distinctly abnormal or unusual.

(*b*) The exterior of the meat shows dew-like moisture, smeariness, or marked iridescence.

(*c*) If the bacterial (coccus and bacillus forms) count exceeds 100,000,000 per gram of the meat substance. It is wholly impracticable to remove the infection mechanically.

(*d*) If eating a piece of the fried meat gives rise to an acrid irritating throat sensation.

A. coccus form enclosed in a gelatinous mass (*Diplococcus mesenteroides*) is quite common upon the exterior of smoked, smoked and salted, and sliced meats.

18. Milk. Raw, Pasteurized and Canned

1. *General.*—The lacteal secretion obtained from the domesticated cow and from other animals, as goat, mare, and ass, is a highly important food article. The chief food ingredients which it contains are casein, fat, and sugar (lactose). The major bulk is water. Milk happens to be an ideal food for many bacteria and raw milk freely exposed to air undergoes complete bacterial decomposition in a comparatively short time, the rate of decomposition depending on temperature, oxygen supply and degree of contamination. The organisms which may be considered as the normal milk decomposers are the group of lactic acid formers, or the milk sourers. These appear to be omnipresent in the air and upon the earth's surface, entering air exposed milks and by their rapid multiplication soon crowd out other associated air bacteria.

The production of pure milk is all important and pure milk can be supplied provided sanitary rules and regulations are strictly observed and enforced.

Temperature and climatic conditions are of great importance in regulating the bacterial contamination of milks. Thus there is in many states and localities, a summer standard and a winter standard. Again, the varied and variable dairying conditions has resulted in the recognition of several grades of milk, as certified, guaranteed, grade A, grade B, etc.

The milk from diseased animals is universally recognized as objectionable and no one would knowingly use such milk. Milk may serve as a carrier of disease, as tuberculosis, various forms of coccic and streptococcic infection, typhoid, dysentery, diphtheria, etc. These are all matters of general knowledge to sanitarians and need not be discussed more fully.

2. *Special.*—Under the compound microscope, ordinary cow's milk may show the following elements.

(*a*) Butter fat globules. Variable in size, occurring singly and more or less agglutinated.[1]

(*b*) Casein granules. Very minute and formless, granular.

(*c*) Body cells. Epithelial cells, leucocytes, red blood corpuscles, pus corpuscles.

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[1] Boiling and pasteurizing causes fat globules to agglutinate

(*d*) Impurities derived from cow, from cow stable, from cattle feed.

(*e*) Impurities derived from milkers.

(*f*) Impurities derived from containers.

(*g*) Impurities derived from air and dust.

(*h*) Pathologic impurities from the milk yielding animals and from the human associates.

As far as the micro-analytical examination of milk is concerned, no attempt is made to identify the different species of micro-organisms which may be present. The essential is to determine whether or not the milk in question is fresh, pure, and wholesome.

3. *Rating.*—Two methods for milk rating must be noted. The older rating based upon plate and tube cultures, still operative or applied in most laboratories, and the more recent rating based upon direct microscopical examination. The older method (plating method) gives evidence of the approximate number of living bacteria present only and is quite limited in scope and significance. The direct microscopical examination gives evidence as to the following.

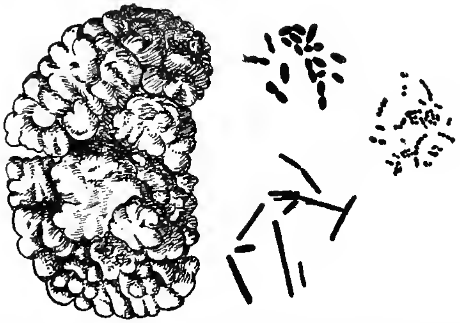

FIG. 78.—Showing a kephir granule or "seed" natural size. This is a mass of milk curd containing the organisms shown to the right which are concerned in the milk fermentation known as kephir formation. These granules are obtainable in the market (the larger importing drug houses). Three predominating micro-organisms occur in the kephir granules, a large bacillus, a streptococcus and a yeast.—(*Marshall.*)

1. Total number of dead and living bacteria present.
2. Body cells of all kinds.
3. Colostrum (fat globules and characteristic ameboid body cells).
4. Dirt and similar impurities present.
5. Butter fat present.

The following extracts from the California State Pure Milk act explains the essentials regarding pure milk.

1. *Tuberculin Test.*—It shall be unlawful for any person, firm or corporation, except in bulk to the wholesale trade, to sell or exchange or offer or expose for sale or exchange for human con-

sumption any milk from cows that have not passed the tuberculin test, until it has been pasteurized by the holding process at a temperature not less than 140°F. for twenty-five minutes; provided, that milk for drinking purposes shall not be heated above 145°F. It shall further be unlawful for any person, firm or corporation to sell or exchange or offer or expose for sale or exchange any milk products except cheese, into the composition of which any milk enters other than that permitted in this section of this act, to be sold at retail. For the purpose of this act milk shall be construed to include cream.

2. *Uninspected Milk.*—It shall be unlawful for any person, firm or corporation to sell or exchange, or offer for sale or exchange, in any city, county or city and county, in which a milk inspection service, approved by the state dairy bureau, has been established, any milk otherwise than as hereinafter provided in this act, and for the purpose of this act, the term "inspecting department" shall be construed to mean the health department of a county or group of counties, city or group of cities, or city and county, maintaining a milk inspection service approved by the state dairy bureau.

3. *Impure Milk.*—All milk, except certified milk, guaranteed milk, grade A milk, and grade B milk, is hereby declared to be impure and unwholesome and must not be sold for human consumption.

4. *Grades.*—For the purpose of this act, milk shall be graded as follows: certified milk, guaranteed milk, grade A milk, grade B milk and milk not suitable for human consumption; provided, that milk not suitable for human consumption shall be plainly so marked.

5. *Guaranteed Milk.*—No person, firm or corporation shall sell or exchange, or offer or expose for sale or exchange, as or for guaranteed milk, any milk, raw or pasteurized, the quality of which is guaranteed by the dealer, without approval in writing of the inspecting department, which milk must be of a higher standard than that required for grade A raw milk.

6. *Grade "A" Milk.*—No person, firm or corporation shall sell or exchange, or offer or expose for sale or exchange, as and for grade A milk, any milk that does not conform to the rules and regulations and the methods and standards for production and distribution of grade A milk adopted by the inspecting department.

Grade A milk shall conform to the following requirements as a minimum: if raw, it shall consist of the clean raw milk from healthy cows as determined by physical examination and by the tuberculin test by a qualified veterinarian under the supervision of the inspecting department, and from dairies that score not less than 70 per cent. on the score card adopted by the United States Bureau of Animal Industry, Department of Agriculture. The tuberculin test must be repeated annually if no reacting animals are found in the herd. If reacting animals are found they must be removed from the herd, and the tuberculin test repeated in six months. All cows are to be fed, watered, housed and milked under conditions approved by the inspecting department. All persons who come in contact with the milk must exercise scrupulous cleanliness and must not harbor the germs of typhoid fever, tuberculosis, diphtheria, or other infectious diseases liable to be conveyed by milk. Absence of such infections shall be determined by cultures and physical examination, to the satisfaction of the inspecting department.

This milk is to be delivered in sterile containers and is to be kept at a temperature established by the inspecting department until it reaches the ultimate consumer, when it must contain less than one hundred thousand bacteria per cubic centimeter. If pasteurized it shall come from cows free from disease as determined by physical examination at least once in six months, by a qualified veterinarian of an inspecting department. It shall contain less than two hundred thousand bacteria per cubic centimeter before pasteurization and less than ten thousand bacteria per cubic centimeter[1] at the time of delivery to the ultimate consumer. Dairies from which this milk is derived must score at least sixty on the score card adopted by the United States bureau of animal industry, department of agriculture.

7. *Grade B Milk.*—No person, firm or corporation shall sell or exchange, or offer or expose for sale or exchange, as and for grade B milk, any milk that does not conform to the following requirements as a minimum: it must be obtained from cows in no way unfit for the production of milk for use by man, as determined by physical examination at least once in six months by a qualified veterinarian of an inspecting department. Before pasteurization such milk shall contain less than one million bacteria per cubic centimeter. After pasteurization it shall contain less than fifty thousand bacteria per cubic centimeter.

Milk for pasteurization must be kept at a temperature established by the inspecting department up to the time of delivery to the pasteurization plant and rapidly cooled after pasteurization to a temperature of 50°F. or below and so maintained to the time of delivery of the same. Pasteurization shall be by the holding method at a temperature not less than 140°F.; provided, that milk for drinking purposes shall not be heated above 145°F.

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[1] These numbers refer to colonies in Petric dish cultures.

Such pasteurizing plant shall be equipped with a self-registering device for record of the time and temperature of pasteurization. Such records shall be kept for two months and be available for inspection by any health department, the state veterinarian or any of his agents, or the state dairy bureau. Pasteurized milk shall be marked with the day of the week of pasteurization and must be delivered to the consumer within forty-eight hours thereafter. If milk is repasteurized, it must not be sold except as not suitable for human consumption.

8. *Milk Not Suitable for Human Consumption.*—Milk not suitable for human consumption may be sold for industrial purposes, provided it be heated to a higher temperature than necessary for pasteurization, and delivered in a distinctive container, plainly marked with the words "Not suitable for human consumption," in letters not less than one-quarter inch in length and one-twelfth inch stroke.

The following limit counts are based upon direct microscopical examination and is intended as a guide to analysts.

TOTAL NUMBER PER CC.

Grades	Bacteria	Body cells	Organic particles	Fat globules
Ordinary	100,000,000	500,000	1,000,000	2,000,000,000 to 4,500,000,000
Certified	20,000,000	40,000	50,000	
Guaranteed	25,000,000	40,000	50,000	
Grade A	20,000,000	40,000	50,000	
Grade B	50,000,000	40,000	75,000	

Canned and dried milks are of prime mportance to the army. The following methods apply to the examination of such milks.

9. *Canned Milk.*—The usual laboratory routine in the examination of canned milks is chemical, ascertaining total solids, butter fat, lactose, sucrose, etc. The usual quality standards for evaporated milks, including the standard of the United States Bureau of Chemistry, are based upon chemical composition rather than upon means for ascertaining possible organic contamination. The Bureau of Chemistry Standard specifies that "evaporated milk should be prepared by evaporating fresh, pure milk obtained from healthy cows." The following method will make it possible to determine the freshness, purity, and wholesomeness of, or the bacterial and other contamination in evaporated milk, *after* such milk has been canned, processed, and offered on the market.

While the processing is intended to and does kill all organisms which may be present in the milk, it does not destroy or decompose them, or render them invisible or unrecognizable under the compound microscope. The microscope will therefore reveal all of the micro-organisms, and also other contaminations, which were introduced or which developed in the milk prior to and up to the very moment of the final processing.

The following findings and recommendations pertain to evaporated milks, whole and skimmed, sweetened and unsweetened:

1. The organisms most commonly present are: (*a*) Cocci, (*b*) Diplococci, (*c*) Diplobacilli, (*d*) Streptococci, (*e*) Bacilli (*f*) Tetracocci (Sarcina), naming them in the order of their relative abundance. Of these groups, the diplococcus, diplobacillus, and streptococcus forms are the most important from the viewpoint of the food bacteriologist.

2. Many of the coccus and diplococcus forms are no doubt derived from the streptococcus forms. Because of the fact that coccus forms may be confused with minute fat globules and non-bacterial organic particles of spherical form, staining methods must be employed in making the count.

3. The diplobacillus forms thus far observed are readily confused with diplococcus forms, because the individual cells are but slightly elongated, the two diameters being as 1 : 1.3. It is therefore recommended that the diplococcus and diplobacillus forms be included in one and the same count.

4. Bacilli are, as a rule, sparingly and irregularly present in evaporated milks. The same may be said of the tetracoccus forms.

5. It is not practicable to make body cell counts of evaporated milks, unless staining is resorted to.

6. The amount of organic debris present in evaporated milk is quite variable in different cans of a given brand of canned milk. It is, however, recommended that milk be examined as to the relative amount of organic debris present, bearing in mind that the careless or inexperienced micro-analyst may confuse casein particles, agglutinated butter fat globules and lactose crystals, with organic debris.

7. Organoleptic testing is of considerable importance in milk examination. Consistency, color, odor, and taste, should be carefully noted.

8. It is also self-evident that the presumptive colon bacillus test would give negative results with all heat-sterilized milks.[1]

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[1] It is a notable fact that pasteurization does not always kill the colon bacilli in milk. Numerous samples of pasteurized milk have been found which subsequently contained practically pure cultures of the colon bacillus.

The following recommendations are made:

A. That the quality and purity of sterile evaporated milks be based upon the following findings given in the order of their importance: (*a*) Diplobacilli, (*b*) Diplococci, (*c*) Streptococcus chains (*d*) Organic debris, other than casein or butter fat.

It is recommended that the diplococcus and diplobacillus forms be included in one and the same count, and that the count be stated as so many pair per cc. Linear groupings of three or more coccus forms are to be counted as streptococci, and the count is to be stated as so many chains per cc.

B. That sterile evaporated milk be declared below standard on the following counts: 60,000,000, or more, pair of diplococci and diplobacilli per cc., or 300,000, or more, chains of streptococci per cc., or both; with or without the presence of body cells or any considerable amount of organic debris, and with or without bacilli, tetracocci, or other associated micro-organisms.

C. That in case of non-sterile evaporated milk, or raw milk intended for the canning and evaporating process, and in inadequately processed canned milk, or milk in imperfectly sealed tins, or milk in unsuitable tins (tins with "Friction caps," for example), the direct microscopical examination be supplemented by the usual plating, tube, and fermentation tube culture methods.

D. That under organic debris there should be included such organic particles as are distinctly recognizable as other than sugar crystals, casein granules or casein masses, or particles of butter fat. It may include the following substances: (*a*) Vegetable tissue elements derived from field, soil, stable manure, or cattle feed. (*b*) Dirt particles. (*c*) Stringy shreds of albuminous matter. (*d*) Variously colored (mostly reddish brown), irregular, amorphous, or somewhat crystalline particles of resinoid character, probably largely of vegetable origin (decomposition products). (*e*) More or less disintegrated and not distinctly recognizable body cells (epithelium, leucocytes, endothelial cells).

These, and other particles of organic debris, are readily observable under the low power of the compound microscope. In homogenized milks the streptococcus chains are often well broken up, becoming largely reduced to diplococcus forms and also to coccus forms.

In the examination of full milks, fresh, evaporated, sweetened or unsweetened, and inclusive of creams, ice creams, etc., a small high speed (2800 revolutions per minute) hand centrifuge is required. Ice creams, creams, sweetened evaporated milks, must be suitably diluted (1 : 5 as a rule) before centrifuging in order to facilitate the separation of the bacteria and organic debris and the butter fat. In case of sweetened evaporated milks, the dilution must be sufficient to dissolve all of the lactose and added sucrose. To hasten the solution of the lactose, heat may be employed.

Place 10 cc. of the milk or the solutions thereof in special two-part (1 cc. + 9 cc.) tubes and centrifuge for ten minutes. Remove the 1 cc. end tube, holding the sediment, and mix the contents thoroughly and from this make the bacterial counts, using dilutions as may be required.

However, the above tedious and time-consuming method need not be employed. Either the Prescott and Breed method, or the general method for food work, elsewhere described, will be found satisfactory and will give results fully as accurate as the above. Creams and ice creams may be examined bacterially by the general method referred to, after making a suitable diluton, usually 1 : 5. Ice creams and creams should not contain more than 100,000,000 bacteria (of all kinds) per cc. Many of the ice creams on the market contain over 500,000,000 bacteria per cc.

The coccus forms and other micro-organisms in heat sterilized milks have lost much of their original staining properties. Dead bacteria generally, especially those killed by moist heat, as a rule, react feebly with the usual stains. The streptococcus form found in evaporated canned milk most generally seen, appears to have the morphological characteristics of the *Streptococcus acidi lactici* of Kruse, which is believed to be entirely harmless to man and to be in normal lactic acid fermentation of milk. It is, however, quite immaterial from the standpoint of the purity and freshness of milk, whether the organisms found are harmless or not.

In numerous samples of canned milk where the coccus forms were counted, the numbers ranged from 15,000,000 to 200,000,000 per cc. and over, and the coccus count as a rule exceeded the sum of the diplobacillus, diplococcus and streptococcus counts in the ratio of 4 : 3.

Based upon the examination of numerous samples of several brands of evaporated skimmed milks, a count of 100,000,000 pair per cc. of diplo forms, as a rule, corresponds to about 150,000,000 coccus forms per cc. or a total of 250,000,000 micro-organisms per cc. There appears to be no fixed number ratio between coccus and diplococcus forms on the one hand and streptococci on the other, hence the suggestion that these groups be given separate rating values.

10. *Dried Milk.*—Perfectly dry milk is becoming more and more common in the market. It is, as a rule, cleaner and freer from micro-organisms than evaporated milk If pure milk is used in its manufacture, the finished product will show very little increase in bacterial contaminations, because the time required for complete drying is very brief. If the finished article is properly canned, it will keep wholesome for several months and longer. The bacterial count (direct) should not exceed 60- to 75,000,000 bacteria of all kinds, per gram of the dry powder. For army use the dried milk is to be given the preference to all other milks. A number of firms are now manufacturing this product, some under special names, as "klim," "milkose," etc.

19. Oysters and Other Shellfish

1. *General.*—Oysters, scallops, clams. abalones, mussels, snails, lobsters, shrimps, and other shellfish and molluscs, occasionally form important articles of diet. Oyster and clam beds may be drawn upon by nearby army encampments. Battle fronts and encampments near streams may use the clams and mussels found in such streams. Canned oysters and other canned shellfish, do not form a regular article of diet in the army. Snails are extensively eaten in France, in Austria, and to a lesser extent also in other countries.

2. *Special.*—The experienced micro-analyst can readily distinguish the representatives of the different species of shellfish. The blood corpuscles and the muscle elements differ. The contents of the digestive tract differ. There are differences in coloring substances.

3. *Rating.*—The organoleptic tests and the microscopical examination are of nearly equal importance in the examination of this class of food. The following should be kept in mind.

(*a*) No shellfish is to be used as food which is found in polluted (sewage) water, sand, or soil.

(*b*) All canned shellfish having a disagreeable ordor should be rejected without further examination.

(*c*) Canned as well as fresh openly kept shellfish (shrimps especially) may give off a marked odor of ammonia (due to bacterial development). Such shellfish should be rejected without further examination.

(*d*) If shellfish of any kind, or the liquor in which shellfish is kept, contains 40,000,000, or more, bacteria (largely bacilli) per gram or per cc., it should be rejected, irrespective of odor, of color changes, or of changes in consistency.

(*e*) The usual presumptive colon bacillus test is impracticable and non-essential in army food analysis.

(*f*) Plating and tube culture methods are likewise impracticable and non-essential.

(*g*) Shellfish decomposes quickly and should be eaten at once, either cooked or fried.

(*h*) Eating shellfish raw, with or without seasoning, or just parboiled, is a dangerous and risky practice and should not be permitted. "Floated," "fattened" or "iced" (stored on ice) oysters should not be eaten. Oyster cocktails should be avoided.

It is generally believed that shellfish (oysters in particular) is easily digested. This is in a measure true, but the heat and energy producing quality of this class of food is far less than that of beef, weight for weight.

20. Pastry

Pastry (pies, cakes, cookies) is not a regular article of diet, neither in the army nor among civilians. Pastry is, as a rule, difficult to digest and tends toward a sluggish liver, sluggish bowels (constipation), and a muddy complexion. Pastry gourmands are physically and mentally sluggish.

Much deception is practiced in pastry making. Bad eggs, wholly worthless egg substitutes, impure shortening, and inferior grade flours are used. Saffron and other yellow coloring substances are added to simulate the use of eggs. Impure sugars are used; dirty and badly contaminated fruits are added. The grossest forms of adulteration occur in pies. The lemon pie filler may consist simply of a nauseous starch paste, with a little lemon flavor, and a little added color. The crust is often filthy, reeking with old rancid and imitation fat and lard shortening. The one time excellent apple pie has degenerated into an inedible mess of malodorous pie crust with old decomposed apple stock. The mince pie is often so in name only. Not only is there no mince meat present, but the fruit used is often dirty and badly contaminated by bacteria, yeasts and mold. It is advised to avoid pastry as much as possible and to eat only that which is properly made and the quality and purity of which can be guaranteed. The pastry eating habit is easily acquired and the consequences of such habit are pernicious, leading to disturbances of digestion, sluggish bowels, and the consequent increase in girth, gas accumulation and constipation, bad complexion, and lessened metal and physical activity.

21. Peas. Ripe, Dried, Green, Canned. *Pisum sativum*

The Department of Agriculture (March 9, 1918) issued the following definitions and standards applicable to canned vegetables, canned peas, and canned pea grades, which will be of assistance to the micro-analyst in examining this important food article.

1. "Canned vegetables are the properly matured and prepared fresh vegetables, with or without the addition of potable water, salt, and sugar, as specified in the separate definitions for the several kinds of canned vegetables, sterilized by heat, with or without previous cooking in vessels from which they take up no injurious substance, and kept in suitable, clean, hermetically sealed container."

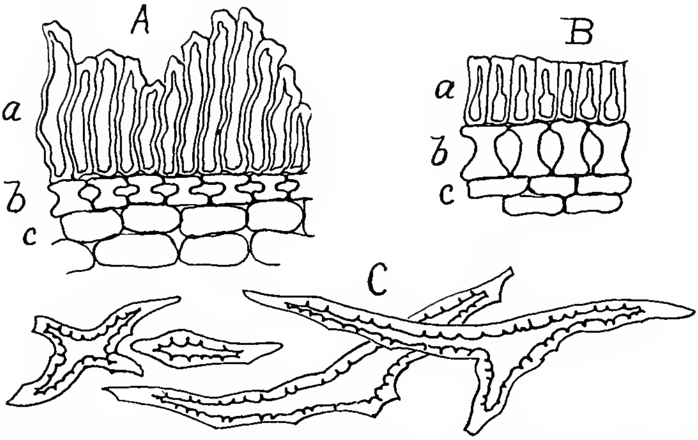

FIG. 79.—Leguminous seed and fruit tissues. A, seed coat of the chick pea (*Cicer arietinum*), also known as Gram or Garbanza bean, and is used as a coffee substitute and as an adulterant of coffee; *a*, palisade cells; *b*, layer of hour glass cells; *c*, parenchyma. B, seed coat of soy bean (*Glycine hispida*); *a*, *b*, *c*, as for A. C, branching sclerenchyma cells of the peanut (*Arachis hypogæa*). Ground peanut shells are much used as an adulterant of ground spices and drugs.

2. "Canned peas are the canned vegetables prepared from the well developed but still tender seeds of the common or garden pea (*Pisum sativum*) by shelling, winnowing and thorough washing, with or without grading and with or without precooking (blanching), and by the addition, before sterilization, of the necessary amount of potable water, with or without sugar and salt."

CANNED PEA VARIETIES

3. "Early peas are peas of early maturing sorts having smooth skin.

4. "Sugar peas, sweet peas, are peas of later maturing varieties having a wrinkled skin and sweet flavor.

Canned Pea Grades

5. "Fancy peas are young, succulent peas of fairly uniform size and color, unless declared to be ungraded for size, with reasonably clear liquor, and free from flavor defects due to imperfect processing.

6. "Standard peas are less succulent peas than the 'fancy' grade, but green and of mellow consistency, of uniform size and color, unless declared to be ungraded for size, with reasonably clear liquor, though not necessarily free from sediment, and reasonably free from flavor defects due to imperfect processing.

7. "Sub-standard peas are peas that are over-mature, though not fully ripened, or that lack in other respects the qualifications for the standard grade."

Canned Pea Sizes

"No. 1 peas are peas which were, before precooking (blanching), small enough to pass through a screen of $\frac{9}{32}$-inch (7 mm.) mesh.

No. 2 peas are peas which were, before precooking (blanching), small enough to pass through a screen of $\frac{10}{32}$-inch (8 mm.) mesh.

No. 3 peas are peas which were, before precooking (blanching), small enough to pass through a screen of $\frac{11}{32}$-inch (8.7 mm.) mesh.

No. 4 peas are peas which were, before precooking (blanching), small enough to pass through a screen of $\frac{12}{32}$-inch (9.75 mm.) mesh.

No. 5 peas are peas which were, before precooking(blanching) small enough to pass through a screen of $\frac{13}{32}$-inch (10.3 mm.) mesh.

No. 6 peas are peas not all of which were, before precooking (blanching), small enough to pass through a screen of $\frac{13}{32}$-inch (10.3 mm.) mesh."

The contaminations of peas are much like those of beans, and all canned peas should be carefully examined microscopically. Canned peas may be sweetened with saccharin, which is unlawful. They may be colored green with copper sulphate. Dried peas may be soaked for a long time and colored and sold for fresh green peas (look for sprouting embryos).

Green peas are more easily digested than ripe peas. Pea flour is used in making soup and as an ingredient of certain sausages (Erbswurst).

Peas are usually canned by themselves, not mixed with sauces, meats, etc., as are beans, and if the processing is properly done, the article may be kept wholesome for a long time.

Peas are widely used and canned as well as ripe peas and the pea flour will be found highly valuable in the army diet. There are other valuable foods derived from the pulse family (Leguminosae) as the lentil (*Lens esculenta*), the peanut (ground nut, pindar, goober) (*Arachis hypogaea*), and the soy bean (soja bean) (*Glycine hispida*). (See also Beans.)

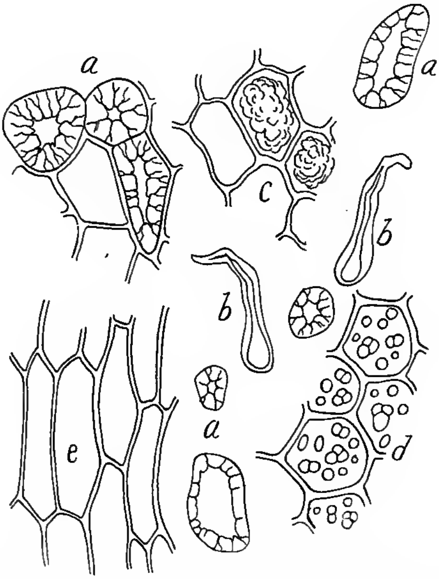

FIG. 80.—Allspice tissues. *a*, sclerenchyma cells from the pericarp; *b*, single-celled trichomes which are few in number but highly diagnostic; *d*, starch bearing pericarp cells; *e*, pericarp parenchyma in longitudinal section. Frequently adulterated with stem tissue and allspice refuse.

22. Spices, Condiments, Relishes, Pickles

1. *General.*—These substances are not foods proper and they are perhaps wholly non-essential to life, yet man has become so accustomed to their use, that most foods would be insipid without them. They do encourage and stimulate digestion and the aromatic spices do have antiseptic properties and may tend to check or prevent intestinal fermentation.

2. *Special.*—The experienced micro-analyst will have no difficulty in identifying the different spices, condiments, and relishes. Spices (pepper, allspice, cloves, capsicum, marjoram, cinnamon, nutmeg, mace, mustard) are very frequently adulterated, but fortunately these adulterations are easily detected because, as a rule, the adulterant is histologically quite different from the spice itself.

3. *Rating.*—Spices may be rated as follows: (*a*) Worthless as a spice. (*b*) Inferior, or poor. (*c*) Fair. (*d*) Good. (*e*) Superior, or extra fine.

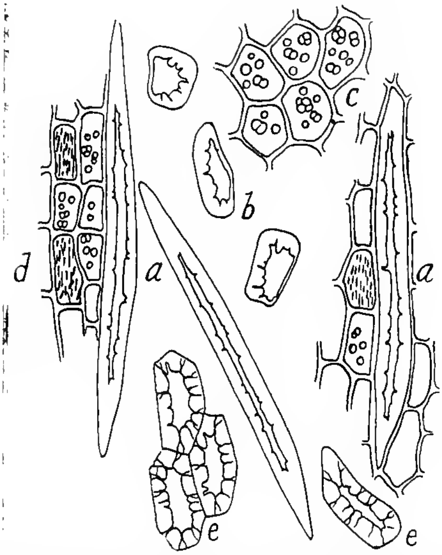

FIG. 81.—Cinnamon. *a*, bast cells; *b*, sclerenchyma cells with unequally thickened walls; *c*, starch bearing bark parenchyma cells; *d*, parenchyma cells showing small elongated crystals; *e*, sclerenchyma cells with equally thickened walls. Frequently adulterated with worthless old barks.

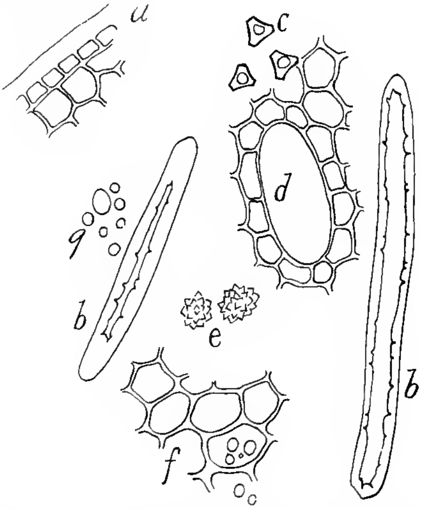

FIG. 82.—Clove tissues. *a*, epidermal tissue in profile view, showing the enormously thickened cuticle; *b*, the very characteristic bast cells, which are few in number; *c*, pollen grains; *d*, oil gland; *e*, aggregate crystals of calcium oxalate. Frequently adulterated with clove stems, exhausted cloves, allspice and allspice stems, refuse, etc.

The organoleptic tests must be combined with the microscopical examination in order that reliable conclusions as to quality may be reached. The following is a list of the more commonly employed spices and their more common adulterants.

(*a*) **Allspice.**—Inferior grades ("grinding nutmegs"), refuse, stems, moldy nutmegs, mold.

(*b*) **Capsicum.**—Corn meal, cereal, seeds, calyx tissue, worthless (nearly tasteless) peppers. Mold may be present.

(*c*) **Cinnamon.**—Inferior to wholly worthless old bark, cassia buds, stems, cereal.

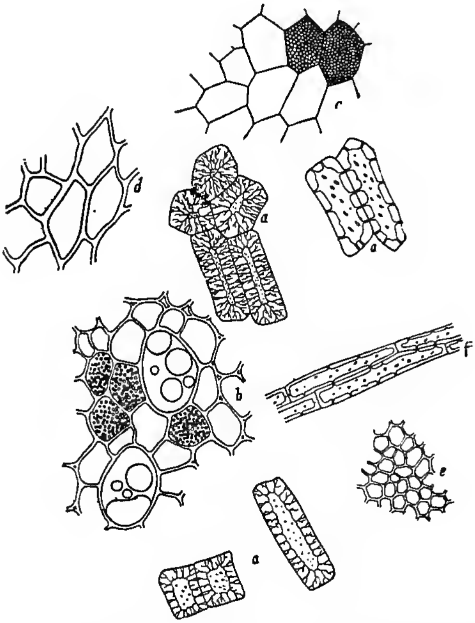

FIG. 83.—Cubeb. *a*, Sclerenchyma; *b*, endosperm, with oil globules and proteid granules; *c*, cells of pericarp; *d*, parenchyma of stalk; *e*, epidermal cells, vertical view; *f*, tracheids.

(*d*) **Cloves.**—Exhausted cloves (gray cloves), clove stems (5 per cent. allowed), allspice, allspice refuse, cereal.

(*e*) **Mace.**—Wild mace (Bombay mace), corn meal, cereal, Macassar mace (Papua mace).

(*f*) **Marjoram.**—Other herbs. Adulteration appears to be the rule.

(*g*) **Mustard.**—Cereal and curcuma, rape seed and other cruciferous seeds, mustard hulls. The most common adulterants are cereal (wheat flour) and curcuma.

(*h*) **Nutmeg.**—"Grinding nutmegs," cereal, other vegetable substances, mold.

(*i*) **Pepper (black).**—Black pepper refuse, stems, grinding peppers, bran, chaff, corn meal, mold.

(*j*) **Pepper (white).**—Cereal (rice), white corn meal, black pepper bleached, mold.

Curry powder is of Hindoo origin and consists of curcuma, cayenne pepper, ginger, coriander, and other aromatic and pungent ingredients. Sage is little used and is often adulterated with other vegetable matter. The relishes are chopped vegetable compounds with vinegar, sugar and spices. They are frequently excessively contaminated by bacteria, yeasts and mold. The vegetable combinations in relishes are innumerable. All relishes should be carefully examined microscopically.

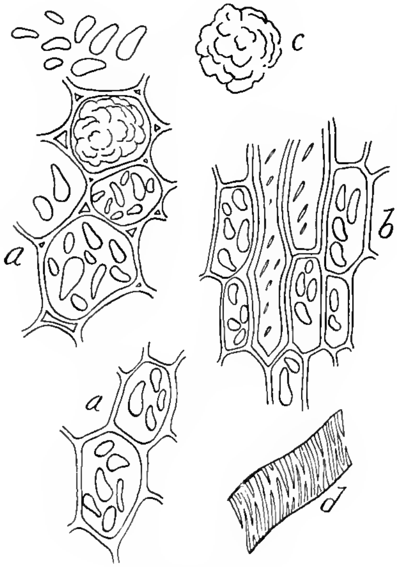

Fig. 84.

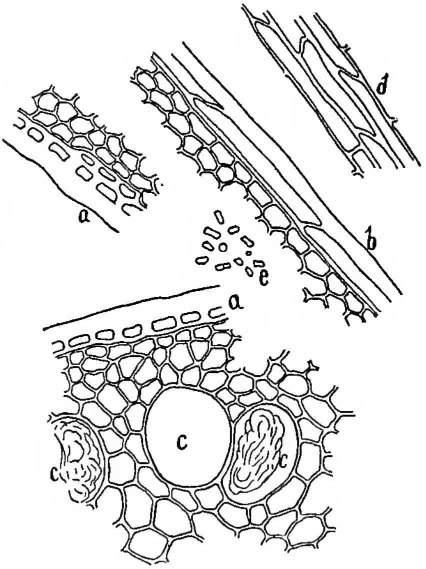

Fig. 85.

Fig. 84.—Ginger. *a* and *b*, parenchyma cells with starch; *c*, yellow resin; *d*, duct of vascular bundle.

Fig. 85.—Mace (true, or Banda mace). *a*, *a*, transverse view of epidermis, including parenchyma cells and large resin bearing cells (*c*); *b*, longitudinal profile view of the epidermal tissue; *d*, vertical view of the epidermal cells; *e*, amylodextrin granules.

Relishes of all kinds and pickles (liquor) should not contain more than 100,000,000 bacteria per cc., and not over 15,000,000 yeast cells per cc., and not more than 15 per cent. of the fields should show mold.

The legal standards of purity (definitions of purity) of the principal spices will be found in Chapter X.

23. Tobacco

Tobacco is known to all and no general discussion is necessary. The injurious effects resulting from the habitual use of tobacco are also generally known. Tobacco is habitually used in the following ways:

(*a*) **Smoking.**—Pipe, cigar, cigarette.

(*b*) **Chewing.**—Plug tobacco, cut plug tobacco, twist tobacco. Rarely also smoking tobacco, cigar ends, and snuff.

(*c*) **Snuffing.**

(*d*) **Snuff Dipping.**

Happily, the snuff habit is becoming quite obsolete. Snuff dipping seems to be most commonly practiced among the poor whites of the Southern states. The chewing habit is more prevalent in rural districts, while smoking prevails in cities. In some cities about 8 per cent. of the entire male population smoke all of the time. Tobacco is a noxious poison and its use should be discontinued.

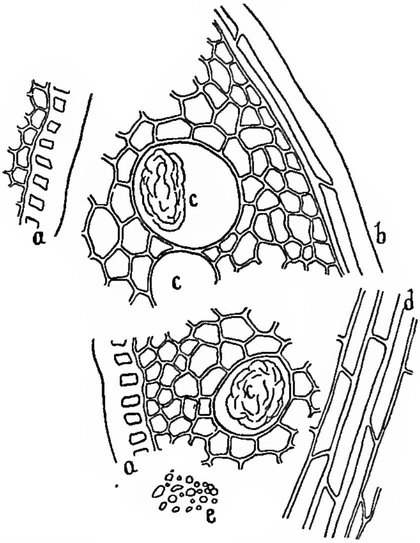

FIG. 86.—False or Bombay mace. *a*, transverse view of the epidermal cells and resin bearing parenchyma; *b*, longitudinal view of epidermis and parenchyma; *c*, resin bearing cells; *d*, vertical view of the epidermal cells; *e*, amylodextrin granules. This is the most common adulterant of true mace.

1. Bacterial diseases may get into cigars and completely modify the aroma.

2. Smoking tobaccos may be adulterated with alfalfa and other foreign vegetable matter. Tobacco stems may be added.

3. Chewing tobaccos usually contain enormous numbers of bacteria, spores, yeasts, and molds. They also contain more or less sand and dirt.

4. Highly contaminated plug tobaccos, cut plug tobaccos, tobacco twists, or any other form of tobacco which is highly contaminated, should not be employed for chewing purposes. They may be smoked. Every effort should be made to break away from the chewing habit.

Those for whom smoking appears to be a necessity should be persuaded to use the mildest tobaccos only (lowest in alkaloidal content).

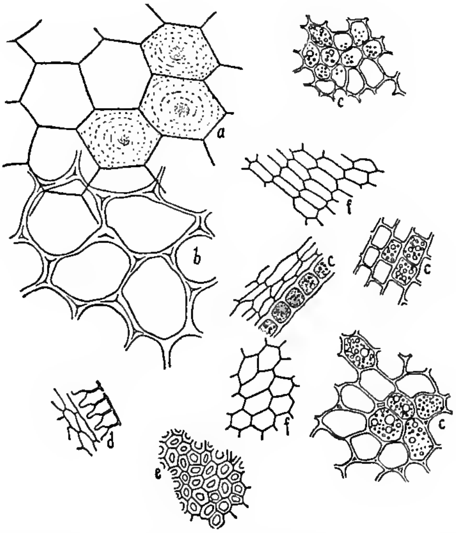

FIG. 87.—White mustard (*Sinapis alba*). *a*, epidermal cells with mucilage; *b*, collenchymatous hypoderm; *c*, proteid and oil bearing parenchyma cells; *d*, palisade tissue, profile view; *e*, palisade tissue, vertical view; *f*, endosperm cells, longitudinal view. Mustard is frequently adulterated, usually with cereal and turmeric.

Men who do not use tobacco should not be compelled to bunk with those who use tobacco, as the tobacco odor is very obnoxious to non-users.

Borrowing and loaning a chew, tobacco pouches, and pipes, should not be permitted, as the practice may spread disease. Smokers should not be permitted to hold pouch or pouch string in the mouth. Smokers should be compelled to keep pipes clean. The use of tobacco, in any form whatsoever, should be discouraged in every way possible.

The following are the more important ill effects due to the use of tobacco.

1. Dimness of vision known as tobacco amblyopia.

2. Weakened action of the heart, incapacitating the user for violent exertion. The heart's action is irregular.

3. Lowered resistance to infection and lowered resistance to the action of bacterial toxins. Tobacco users succumb to disease more readily.

4. Shortness of breath. The respiratory movement is irregular and weak.

5. The tobacco habit in the young impairs general nutrition to a marked degree. Physical, mental, and moral weakness results.

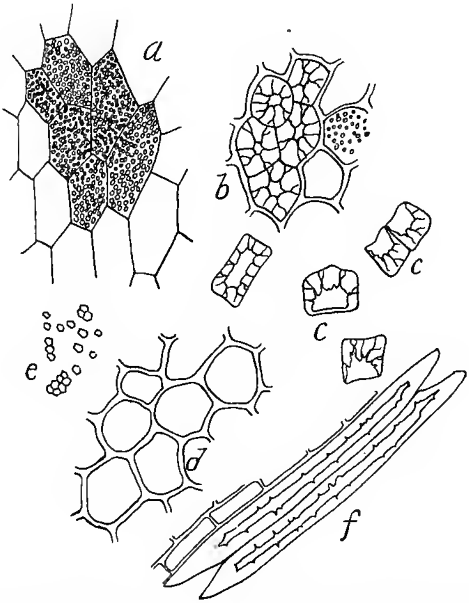

FIG. 88.—Black pepper tissue. *a*, endosperm cells filled with very minute starch from the pericarp; *e*, rice starch. Ground rice is a very common adulterant of pepper; *f*, sclerenchymatous bast from the stem tissue of pepper.

6. Angina pectoris is far more prevalent among tobacco users than among abstainers from tobacco.

7. Various disorders of the digestive tract result from the long continued use of tobacco. The most important of these is chronic nervous dyspepsia.

8. Frequently the offspring of heavy users of tobacco inherit serious nervous disorders (malnutrition, nervousness, general weakness, tendency to tuberculosis).

The microscopical examination of tobacco includes.

(*a*) The recognition of the tobacco tissue elements, the most diagnostic being the simple, two to six-celled, rather thin-walled trichomes; the glandular trichomes (with one to six or eight secreting end cells); the parenchyma cells filled with microcrystalline calcium oxalate; and, the vascular tissue elements.

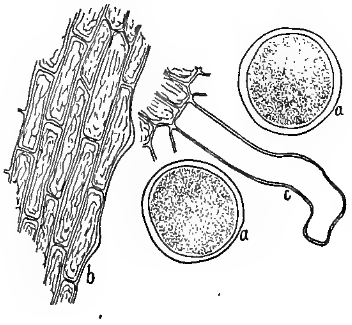

FIG. 89.

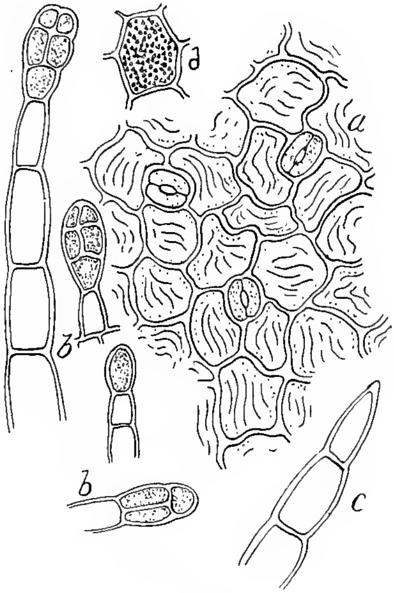

FIG. 90.

FIG. 89.—Saffron (*Crocus sativus*). *a*, Pollen grains; *b*, tissue of style, cells with red coloring matter; *c*, trichome of stigma.

FIG. 90.—Tobacco. *a*, epidermal tissue; *b*, types of glandular trichomes; *c*, simple trichome; *d*, leaf parenchyma cells filled with very minute crystals of calcium oxalate. May be adulterated with foreign leaves and with tobacco stems.

(*b*) The recognition of added tobacco stems.

(*c*) The recognition of vegetable tissues other than tobacco.

(*d*) The estimation of dirt, sand, bacteria, spores, yeasts, and mold.

X. LEGAL STANDARDS OF PURITY

The food analyst should be familiar with the legal standards of the purity of food substances. The legal standards are mere definitions and are, as a rule, so worded as to specify the purity and quality requirements of the food from the health-point of the consumer. It must however, not be supposed that the definitions presume to state what the scientific purity and quality criteria shall be, as employed by the analysts in the laboratories. To illustrate; according to the legal definition, milk is the clean lacteal secretion obtained from one or more healthy cows. The food analysts determine, or have determined, that such milk contains few bacteria, is quite free from dirt and contains 3.50 per cent., or more, of butter fat, etc. If it is found that a given sample of milk contains 500,000,000, or more, bacteria per cc., among them being the colon bacillus, and in addition dirt, cow manure, and other impurities, and tests only 2.35 per cent. butter fat, then the milk does not conform to the legal definition and is pronounced adulterated. The legal definitions do not presume to state the analytical findings upon which the purity rubric is based.

The following legal definitions are adopted by the California State Board of Health and are in all essentials like those adopted by the Bureau of Chemistry of the United States Department of Agriculture.

1. Animal Products

A. Meats and the Principal Meat Products

(*a*) **Meats.**—1. *Meat, flesh,* is any clean, sound, dressed, and properly prepared edible part of animals in good health at the time of slaughter, and if it bears a name descriptive of its kind, composition, or origin, it corresponds thereto. The term "animals," as herein used, includes not only mammals, but fish, fowl, crustaceans, mollusks, and all other animals used as food.

2. *Fresh meat* is meat from animals recently slaughtered and properly cooled until delivered to the consumer.

3. *Cold storage meat* is meat from animals recently slaughtered and which has been held in cold storage at a temperature of 40°F., or below, for a period exceeding thirty days.

4. *Salted*, *pickled*, and *smoked meats* are unmixed meats preserved by salt, sugar, vinegar, spices, or smoke, singly or in combination, whether in bulk or in suitable containers.[1]

(*b*) **Manufactured Meats.**—1. *Manufactured meats* are meats not included in paragraphs 2, 3, and 4, whether simple or mixed, whole or comminuted, in bulk or in suitable containers,[1] with or without the addition of salt, sugar, vinegar, spices, smoke, oils, or rendered fat. If they bear names descriptive of kind, composition, or origin, they correspond thereto and when bearing such descriptive names, if force or flavoring meats are used, the kind and quantity thereof are made known.

(*c*) **Lard.**—1. *Lard* is the rendered fresh fat from hogs in good health at the time of slaughter, is clean, free from rancidity, and contains, necessarily incorporated in the process of rendering, not more than one (1) per cent. of substances, other than fatty acids and fat.

2. *Leaf lard* is lard rendered at moderatly high temperatures from the internal fat of the abdomen of the hog, excluding that adherent to the intestines, and has an iodin number not greater than sixty (60).

3. *Neutral lard* is lard rendered at low temperatures.

B. Milk and Its Products[2]

---

[1] Suitable containers for keeping moist food products such as sirups, honey, condensed milk, soups, meat extracts, meats, manufactured meats, and undried fruits and vegetables, and wrappers in contact with food products, contain on their surfaces, in contact with the food product, no lead, antimony, arsenic, zinc or copper or any compounds thereof or any other poisonous or injurious substance. If the containers are made of tin plate they are outside-soldered and the plate in no place contains less than one hundred and thirteen (113) milligrams of tin on a piece five (5) centimeters square or one and eight-tenths (1.8) grains on a piece two (2) inches square.

The inner coating of the containers is free from pinholes, blisters, and cracks.

If the tin plate is lacquered, the lacquer completely covers the tinned surface within the container and yields to the contents of the container no lead, antimony, arsenic, zinc or copper or any compounds thereof, or any other poisonous or injurious substance.

[2] The standards for milk and its products established by the legislature of California, in 1911, are not in all respects identical with the federal standards. In so far as they differ, the act of 1911 is believed to have superseded the federal standard as to sales within the state of California. Sections 28 to 36 of the act of April 21, 1911 Statutes, 1911, amended 1915, are as follows:

Sec. 28. It shall be unlawful for any person to produce, manufacture or prepare for sale, or to sell or offer for sale, or have on hand for sale, any milk, including condensed or evaporated milk, or any product of milk, that is adulterated within the meaning of this act. The words "product of milk" as used in this act, shall not apply to any product into which milk, or a product of milk, may enter as an ingredient or component of a good product that does not consist of milk, or milk products alone, such as pastry, and confectionery; *provided*, that this section shall not be construed to prevent the use of common salt (chloride of sodium) in dairy products. Any label, printed matter, or advertising or descriptive matter appearing upon, or in connection with any package, parcel or quantity of milk or milk products when being sold, offered for sale, or having on hand for sale, and having reference to the article being sold, offered for sale, or on hand for sale, shall conform to the provisions of this act, and if it fails to conform to the provisions of this act, such article shall be deemed adulterated within the meaning of this act. It shall be unlawful for any person under this act, when selling, or offering for sale, or having on hand for sale, milk or any product of milk to use the words "milk," "condensed milk," "sweetened condensed milk," "skim milk," "condensed skimmed milk," "evaporated cream," "cream," "butter," "cheese," "buttermilk," "ice cream," or "ice milk," either verbally, or printed or written on any label or printed matter, in connection with the sale, or offering for sale, or having on hand for sale, of milk or any product of milk, or upon any bill of fare used in any hotel, restaurant or other places where meals are served, when the article shall not conform to the standards and provisions of section twenty-nine of this act.

SEC. 29. Milk and the products of milk enumerated in this section shall be deemed adulterated within the meaning of this act if it or they shall not conform to the following definitions and standards:

(1) *Milk* is the fresh, clean, lacteal secretion all parts of which within forty-eight hours, if raw, and within sixty hours, if pasteurized, last prior to its delivery to the consumer or purchaser shall have been obtained from the udder by the complete milking of one or more healthy cows, properly fed and kept, excluding that obtained within fifteen days before and five days after calving, and contains not less than 3 per cent. of milk fat, and not less than 8.5 per cent. of solids—not fats.

(2) *Skim milk* is milk from which a part or all of the cream has been removed and contains not less than 8.8 per cent. of milk solids.

(3) *Condensed milk* or evaporated milk, is milk from which a considerable portion of water has been evaporated. The standard of purity of condensed milk and evaporated milk shall be that proclaimed and established by the secretary of the United States department of agriculture.

(4) *Condensed skim milk* is skim milk from which a considerable portion of water has been evaporated, and contains not less than 18 per cent. of milk solids.

(5) *Cream* is that portion of milk, rich in milk fat which rises to the surface of milk on standing, or is separated from it by centrifugal force, is fresh and clean and contains not less than 18 per cent. of milk fat.

(6) *Evaporated cream,* or clotted cream, is cream from which a considerable portion of water has been evaporated.

(7) *Milk fat,* or butter fat, is the fat of milk and has a Reicher-Meissel number not less than twenty-four and a specific gravity not less than .905 (40°C.).

SEC. 31. All wagons, vehicles, or carts from which market milk, cream, butter, ice cream, buttermilk, or ice milk are sold, marketed, delivered, or peddled, shall have the name and address of the owner plainly painted thereon, in letters at least three inches high, and one and a half inches wide, on both sides of such vehicle.

SEC. 32. It shall be unlawful for any person, firm, or corporation to manufacture for sale, sell, or furnish with meals or drinks which are sold, any frozen edibles, made principally of skimmed milk, or principally of milk, unless the same shall conform to the definitions and standards herein fixed in section twenty-nine for "ice milk" or "ice cream."

SEC. 33. It shall be unlawful for any person to produce, manufacture or prepare for sale, or to sell, or to offer for sale, or to have on hand for sale, any milk, or product of milk, to which has been added, or that may contain, any compound of boron, salicylic acid, formaldehyde, or other chemical or substance for the purpose of preventing or delaying fermentation or souring. It shall be unlawful for any person to produce, manufacture or prepare for sale, or to sell, or to offer for sale, or to have on hand for sale, any milk, cream or condensed milk to which any coloring matter has been added by any person, or to which any gelatin or other substance has been added by any persons to increase the consistency of such milk, cream or condensed milk, so as to make such milk, cream or condensed milk appear richer or of better quality; *provided*, that this section shall not be construed to prohibit the use of harmless coloring matter and common salt (chloride of sodium) in butter and cheese.

SEC. 34. It shall be unlawful for any person, firm or corporation, manufacturing any frozen goods, which do not conform to the standards and provisions of this act for ice cream, to sell, or offer to sell, or represent the same as ice cream, or under the name of ice cream; and all frozen goods which do not conform to the standards and requirements of this act for "ice cream," but which do conform to the standards and requirements for "ice milk" herein, for the purpose of this act shall be known as "ice milk," and shall be sold and designated as "ice milk," and not otherwise, and shall be billed as "ice milk," and every person, firm or corporation selling, furnishing or delivering to any person any such "ice milk" shall distinctly inform the purchaser at the time in each and every instance that the said goods are "ice milk." The absence of such declaration shall always be construed as a representation on the part of the vendor that the goods are ice cream. Every tub, receptacle or packer in which there shall be kept, sold, or delivered, at any time, any "ice milk," as herein defined, shall have conspicuously and securely attached thereto a durable tag, giving the name and address of the manufacturer or vendor of the same, and containing the words "ice milk" in letters at least one inch high and one-half inch wide, and containing no other reference to the name or character of the goods therein contained. The absence of such tag or label shall always be construed as a representation on the part of the maker or vendor that said goods are ice cream. Every wagon, vehicle, or cart in or from which any "ice milk" shall be sold, furnished, delivered or peddled, shall have plainly and durably painted on both sides thereof, the name and address of the owner, in letters at least three inches high and one and a half inches wide, and also the words "ice milk" on each side thereof, in letters at least four inches high, and two inches wide, and there shall be no other reference to the name or character of the goods being sold or delivered. The absence of such words and letters shall always be construed as a representation on the part of the owner or vendor that said goods are ice cream. Every person, firm or corporation, who sells, keeps for sale, delivers, or furnishes in connection with meals, or in connection with drinks, or otherwise, any ice milk, within the meaning of this act, to be use or eaten on the premises where sold, shall keep at all times posted or hung in at least two conspicuous places within the premises, and in plain view of the public, durable signs having printed or painted thereon the words "we sell ice milk" or "we serve ice milk," in letters at least four inches high and two inches wide. The absence of such signs, words and letters, as herein required shall always be construed as a representation on the part of the owner, or person selling or serving the goods, that they are ice cream. It shall be unlawful for any person, firm or corporation to manufacture, sell, deliver, furnish, serve, or keep on hand any ice milk, within the meaning of this act, unless the same is done in compliance with all the requirements hereof.

SEC. 35. Every person, firm, or corporation, who shall at any creamery, cheese factory, or private dairy, manufacture cheese in the state of California, shall at the place of manufacture, brand distinctly and durably on the bandage of each and every cheese manufactured, and upon the package or box, when shipped, the grade of cheese manufactured, as follows: "California full cream cheese." "California half skin cheese." and "California skim cheese."

All brands for branding the different grades of cheese shall be procured from the state dairy bureau, and said bureau is hereby directed and authorized to issue to all persons, firms, or corporations, upon application therefor, uniform brands, consecutively numbered, of the different grades herein, specified in section thirty-five of this act. The state dairy bureau shall keep a record of each and every brand issued, and the name and location of the manufacturer receiving the same. No manufacturer of cheese in the state of California, other than the one to whom such brand is issued, shall use the same, and in case of a change of location, the party shall notify the bureau of such change. The different grades of cheese are hereby defined as follows: Such cheese only as shall have been manufactured from pure milk, and from which no portion of the butter fat has been removed by skimming or other process, and having not less than 50 per cent. of butter fat in the water-free substance, shall be branded as "California full cream cheese;" and such cheese only as shall be made from pure milk, and having not less than 25 per cent. of butter fat in the water-free substance, shall be branded "California half skim cheese;" and such cheese only as shall be made from pure skim milk shall be branded "California skim cheese;" *provided*, that nothing in this section shall be construed to apply to "Edam," "Brickstein," "Pineapple," "Limburger," "Swiss," or hand-made cheese, not made by the ordinary Cheddar process. No person, firm or corporation shall sell, or offer for sale, any cheese, manufactured in the state of California, not branded by an official brand and of the grade herein defined in section thirty-five of this act.

SEC. 36. The word "persons," as used in this act, shall be construed to import both the singular and plural, as the case demands, and shall include individuals, corporations, companies, societies and associations. When construing and enforcing the provisions of this act, the act, omission or failure of any employee, officer, agent or other person, acting for or employed by any individual, corporation, company, society or association, within the scope of his employment or office, shall in every case also be deemed to be the act, omission or failure of such individual, corporation, company, society or association, as well as that of the person. The provisions of this act shall be construed to apply to hotel keepers, restaurant keepers and boarding-house keepers or any person who shall serve meals and accept money therefor.

(*a*) **Milks.**—1. *Milk* is the fresh, clean lacteal secretion all parts of which within forty-eight hours, if raw, and within sixty hours, if pasteurized, last prior to its delivery to the consumer or purchaser shall have been obtained from the udder by the complete milking of one or more healthy cows, properly fed and kept, excluding that obtained within fifteen days before and five days after calving, and contains not less than 3 per cent. of milk fat, and not less than 8.5 per cent. of solids—not fat.

2. *Blended milk* is milk modified in its composition so as to have a definite and stated percentage of one or more of its constituents.

3. *Skim milk* is milk from which a part or all of the cream has been removed and contains not less than eight and eight-tenths per cent. of milk solids.

4. *Pasteurized milk* is milk that has been heated below boiling but sufficiently to kill most of the active organisms present and immediately cooled to 50° Fahrenheit or lower.

5. *Sterilized milk* is milk that has been heated at the temperature of boiling water or higher for a length of time sufficient to kill all organisms present.

(8) *Butter* is the clean, nonrancid product made by gathering in any manner the fat of fresh or ripened milk or cream into a mass, which also contains a small portion

of the other milk constituents, with or without salt, and a harmless coloring, and contains not less than eighty per cent. of milk fat.

(9) *Cheese* is the sound, solid, and ripened product made from milk or cream, by coagulating the casein thereof with rennet or lactic acid, with or without the addition of ripening ferments and seasoning, and with or without salt and harmless coloring matter. All cheese marked "full cream cheese," or "full milk cheese," must contain in the water-free substance not less than fifty per cent. of milk fat. All cheese marked "half skim cheese," must contain in the water-free substance not less than twenty-five per cent. of milk fat. All cheese not plainly marked or branded as to its quality must contain in the water-free substance not less than fifty per cent. of milk fat.

(10) *Buttermilk* is that portion of the cream which remains after the separation and removal therefrom of the butter fat in the process of churning, without the addition of water.

(11) *Ice cream* is the frozen product, made from pure sweet milk or condensed milk or cream and sugar with or without a harmless flavoring or coloring, and contains not less than ten per cent. of milk fat, and not more than six-tenths of one per cent. of pure and harmless vegetable gum or gelatin.

(12) *Fruit ice cream* is the frozen product made from pure, sweet cream, sugar, and sound, clean, mature fruits, and contains not less than eight per cent. of milk fat and not more than six-tenths of one per cent. of pure and harmless vegetable gum or gelatin.

(13) *Nut ice cream* is the frozen product made from pure, sweet, cream, sugar, and sound, nonrancid nuts, and contains not less than eight per cent. of milk fat, and not more than six-tenths of one per cent. of pure and harmless vegetable gum or gelatin.

(14) *Ice milk* is the frozen product, containing less fat than ice cream, and made from pure, sweet milk and sugar, with or without a harmless flavoring or coloring, and contains not less than two and four-tenths per cent. of milk fat, and not more than six-tenths of one per cent. of pure and harmless vegetable gum or gelatin.

(15) The process of pasteurization, as applied to milk, skim milk, cream and milk products, is hereby defined to be a process for the elimination therefrom of organisms harmful to human beings, which process shall consist of uniformly heating such milk, skim milk or cream, as the case may be, to a temperatureof not less than one hundred forty degrees Fahrenheit and of holding the same at the said temperature for a period of not less than twenty-five minutes, and immediately thereafter of cooling the same to a temperature of not above fifty degrees Fahrenheit; *provided*, that when cream is pasteurized to be used and is used in the manufacture of butter, or when milk is pasteurized to be used and is used in the manufacture of cheese, and where the process of ripening or starting in each case is to be commenced immediately, then it shall not be required that such cream or milk be cooled to a lower degree than is necessary for such ripening or starting. All pasteurized cream or milk used in the manufacture of pasteurized butter and cheese, respectively, shall be pasteurized at and in the plant where such butter or cheese, as the case may be, is manufactured therefrom. Repasteurization of any milk is hereby expressly forbidden.

Also all apparatus used for the pasteurization of milk, skim milk or cream shall be kept in strictly clean and sanitary condition and shall be equipped with a recording thermometer device which will accurately record the temperature to which and the length of time for which the pasteurized product has been heated. All recording thermometer devices used in the pasteurization of any such milk, skim milk or cream must be approved by and at all times subject to the approval of the state dairy bureau, the state board of health, and of all other state, county and municipal officers charged with the enforcement of laws and ordinances respecting dairy products or the public health; and all persons, firms or corporations using pasteurizing apparatus within the state of California shall preserve and keep on file, for a period of not less than two months after the same are made, all records made by such thermometer, or in lieu of such preservation may deliver such records to any public officer authorized by law or ordinance to receive the same, and said records shall, at all times, be open to the inspection of the state dairy bureau, the state board of health, and of all other state, county and municipal officers charged with the enforcement of laws and ordinances respecting dairy products or the public health.

SEC. 30. It shall be unlawful for any person; firm or corporation to sell, exchange or deliver, or to offer for sale, exchange or delivery, or to cause or permit to be sold, exchanged or delivered, or to be offered for sale, exchange or delivery, or to have in possession for sale, exchange or delivery, any milk from which any part of the cream shall have been removed, or any skimmed milk, unless the same be offered for sale and sold as skimmed milk, or unless there shall be attached to the outside of every vessel, can or package from or in which such skimmed milk is sold or held for exchange or delivery, a tag upon which shall be printed in black letters at least one inch in height the word "skim" or the words "skimmed milk."

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Pumpkin (pollen), 91
Pyrethrum powder, 114
Pyrethrum (trichomes), 110, 113

Quillaja (bast), 96

Rhamnus (bark), 111
Rice tissue, 106
Rye (starch), 94
Rye (trichomes), 110

Saffron (pollen), 91
Sago (starch), 93
Santonica (pollen), 91
Sclerenchyma cell types, 97
Scutellaria (pollen), 91
Senna leaf, 117
Soap bark (bast), 96
Spongy tissue (bean), 107
Spongy tissue (calamus), 115
Spores (lycopodium), 119
Starch (polarized), 92
Starches, 93, 94
    Arrowroot
    Bean
    Buckwheat (starch), 99
    Canna
    Cassava
    Corn
    Cycas
    Dextrinized
    Dioscorea
    Ginger
    Heated
    Manihot
    Maranta
    Potato
    Rye
    Sago
    Tapioca
    Tous le mois
    Wheat
    Yam
Stems (clove), 102
Suberized tissue, 111

Tea leaf (sclerenchyma), 97
Tous le mois (starch), 93
Tracheids (pine), 100
Trichomes (mallow), 108
Trichomes (types), 110

Ulmus (bark), 96

Walnut shells, 104
Wheat (starch), 94
Wheat tissue, 195
Wheat (trichomes), 110
Willow (bast), 96

Yam (starch), 93

6. *Condensed milk*, evaporated milk, concentrated milk, is the product resulting from the evaporation of a considerable portion of the water from the whole, fresh, clean, lacteal secretion obtained by the complete milking of one or more healthy cows, properly fed and kept, excluding that obtained within fifteen days before and ten days after calving, and contains, all tolerances being allowed for, not less than twenty-five and five-tenths per cent. (25.5 %) of total solids and not less than seven and eight-tenths per cent. (7.8 %) of milk fat.

7. *Sweetened condensed milk* is milk from which a considerable portion of water has been evaporated and to which sugar (sucrose) has been added, and contains not less than twenty-eight (28) per cent. of milk solids, of which not less than twenty-seven and five-tenths (27.5) per cent. is milk fat.

8. *Condensed skim milk* is skim milk from which a considerable portion of water has been evaporated, and contains not less that 18 per cent. of milk solids.

9. *Buttermilk* is the product that remains when butter is removed from milk or cream in the process of churning.

10. *Goat's milk, ewe's milk, et cetera,* are the fresh, clean, lacteal secretions, free from colostrum, obtained by the complete milking of healthy animals other than cows, properly fed and kept, and conform in name to the species of animal from which they are obtained.

(*b*) **Cream.**—1. *Cream* is that portion of milk, rich in milk fat, which rises to the surface of milk on standing, or is separated from it by centrifugal force, is fresh and clean and contains not less than eighteen (18) per cent. of milk fat.

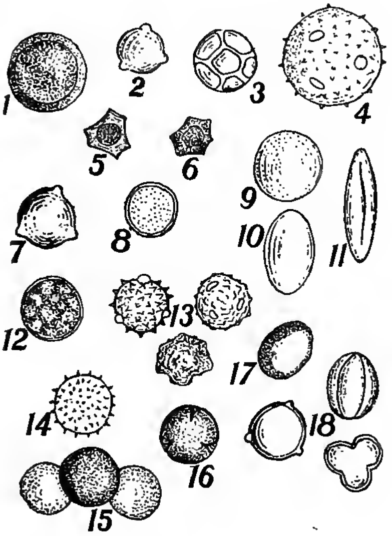

FIG. 91.

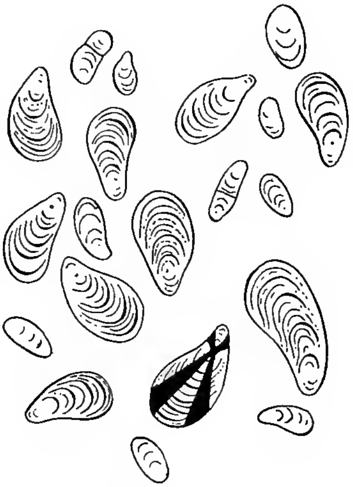

FIG. 92.

FIG. 91.—**Types of Pollen Grains.**—1. Saffron flower. 2. Flax. 3. Pink. 4. Pumpking and squash. 5. Cloves. Mature pollen grain. 6. Cloves. Immature pollen grain. 7. Onagraceæ. *Circea lutitiana* (Enchanter's Nightshade). 8. Scutellaria. 9. Mallow. Distended by moisture. 10. Mallow. Normal form. 11. Albuco. 12. *Lobelia inflata.* 13. Compositæ, showing one mature and two immature pollen grains. 14. Hibiscus. 15. Pine pollen. 16. Santonica. 17. Mentha species. 18. *Hyoscyamus niger.*

FIG. 92.—**Potato Starch.**—The granules are large and the markings (hili, lamellations) are distinct. The cross bands under the polarizer are very distinct. Potato starch, mounted in water, makes a good test object for judging the resolving power of objectives. Dried and ground potatoes and potato parings are sometimes used for adulterating purposes.

2. *Evaporated cream, clotted cream,* is cream from which a considerable portion of water has been evaporated.

(*c*) **Milk Fat or Butter Fat.**—1. *Milk fat, butter fat,* is the fat of milk and has a Reichert-Meissel number not less than twenty-four (24) and a specific gravity not less than 0.905 $(\frac{40°C.}{40°C.})$

(*d*) **Butter.**—1. *Butter* is the clean, nonrancid product made by gathering in any manner the fat of fresh or ripened milk or cream into a mass, which also contains a small portion of the other milk constituents, with or without salt, and a harmless coloring, and contains not less than 80 per cent. of milk fat.

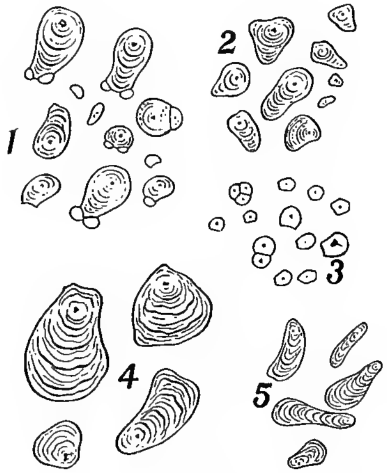

FIG. 93.

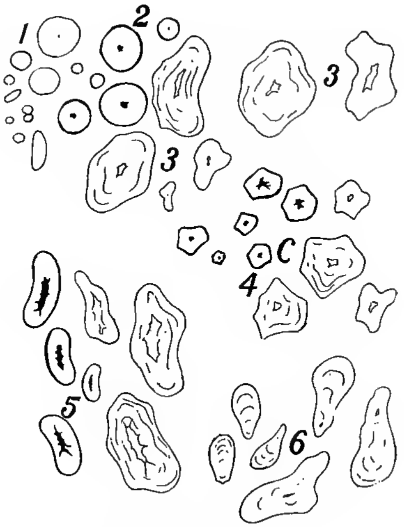

FIG. 94.

FIG. 93.—**Starches.**—1. Sago starch from *Cycas revoluta* (Cycadaceæ). The commercial article known as sago is usually in the form of small granules (pearl sago). There are many false sagos made from other than Cycad or Palm starch. Much of this false sago is made from corn starch.

2. Canna starch from several species of Canna. The markings are very distinct, the hili being at the larger end as a rule. Also called arrowroot (*tous le mois* arrowroot).

3. Cassava or tapioca starch from the tuberous roots of *Manihot utillissima* and other species of Manihot. Simple and compound granules; the granules are largely separated in the processing, thus giving the appearance of simple granules. Their compound origin is, however, recognizable by the contact facets.

4. Maranta starch (Arrowroot starch) from *Maranta arundinaceæ* (Marantaceæ). The granules have many of the structural characteristics of potato starch.

5. Yam starch from several species of Dioscorea (Dioscoreaceæ).

FIG. 94.—**Dextrinized Starch.**—The process of baking and cooking causes the starch granules to undergo marked structural changes. They become much enlarged, the outline becomes quite indistinct and the hili and lamellations are distorted and correspondingly indistinct. 1. Normal wheat starch granules. 2. Normal rye starch granules. 3. Dextrinized wheat and rye granules. 4. Normal and dextrinized corn starch. 5. Normal and dextrinized bean starch. 6. Normal and dextrinized ginger starch.

2. *Renovated butter, process butter,* is the product made by melting butter and reworking, without the addition or use of chemicals or any substances except milk, cream, or salt, and contains not more than sixteen (16) per cent. of water and at least eighty-two and five-tenths (82.5) per cent. of milk fat.

(*e*) **Cheese.**— 1. *Cheese* is the sound, solid, and ripened product made from milk or cream, by coagulating the casein thereof with rennet or lactic acid, with or without the addition of ripening ferments and seasoning, and with or without salt and harmless coloring matter. All cheese marked "full cream cheese," or "full milk cheese," must contain in the water-free substance, not less than 50 per cent. of milk fat. All cheese marked "half skim cheese," must contain in the water-free substance not less than 25 per cent. of milk fat. All cheese not plainly marked or branded as to its quality must contain in the water-free substance not less than 59 per cent. of milk fat.

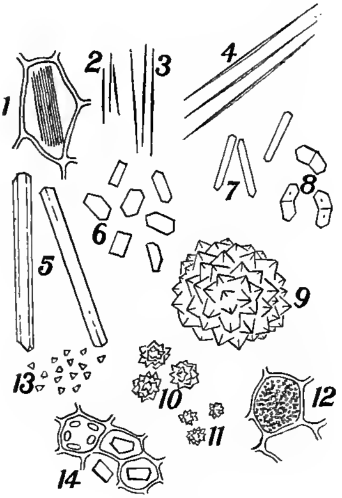

FIG. 95.

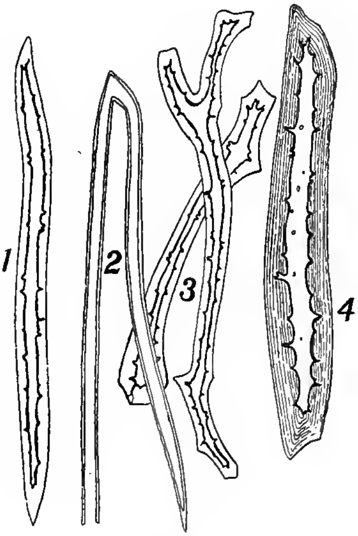

FIG. 96.

FIG. 95.—**Types of Crystals of Calcium Occurring in Different Plants.**—1. A parenchyma cell containing a bundle of needle shaped (acicular) crystals of calcium oxalate (raphide). 2, 3, 4, Acicular crystals differing in length, as they occur in Scilla and in other representatives of the liliaceous groups of plants. 5. Much elongated prismatic crystals as they occur in Quillaja and in *Iris florentina*. 6. Prismatic crystals very widely distributed in the plant kingdom. 7. Elongated prismatic crystals. 8. Twin crystals as they occur in Ulmus bark. 9. Very large aggregate crystals very widely distributed in the vegetable kingdom. 12, 13. Very minute prismatic (pyramidal) crystals as they occur in Belladonna. 14. Prismatic crystals as they occur in Hyoscyamus and in other plant groups.

Calcium oxalate crystals are among the highly diagnostic structural characteristics of drug plants and should be studied not only as to form but also as to size. They are not dissolved in the usual mounting media and are not destroyed by heat. They dissolve slowly in the stronger acids (hydrochloric acid).

FIG. 96.—**Types of Bast Cells as They Occur in Barks and in Other Plant Parts.** 1. Shorter bast cell as they occur in the cinnamon barks. 2. Typical bast cell (showing a portion of a cell only) as they occur in willow bark, in Ulmus, in Mezereon, etc. 3. Branching bast cells as they occur in Quillaja and in Prunus bark. 4. Greatly thickened sclerenchymatous bast cells as they occur in the Cinchonas.

2. *Skim milk cheese* is the sound, solid, and ripened product, made from skim milk, by coagulating the casein thereof with rennet or lactic acid, with or without the addition of ripening ferments and seasoning.

3. *Goat's milk cheese, ewe's milk cheese, et cetera*, are the sound, ripened products made from the milks of the animals specified, by coagulating the casein thereof with rennet or lactic acid, with or without the addition of ripening ferments and seasoning.

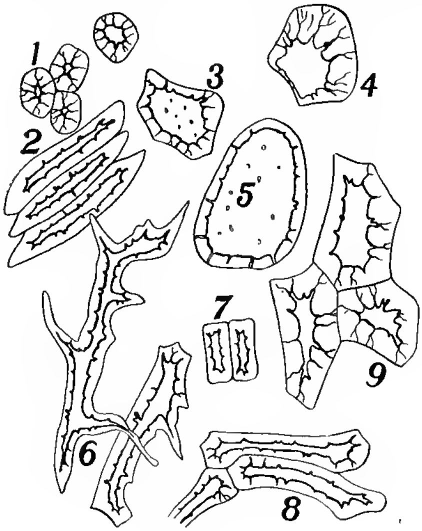

FIG. 97.

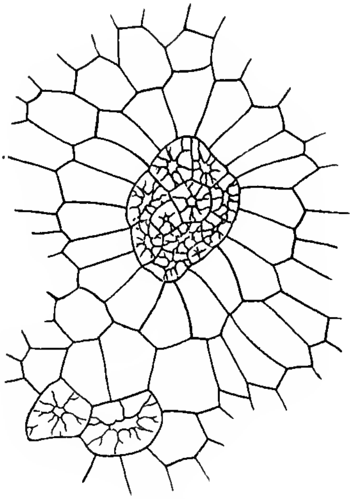

FIG. 98.

FIG. 97.—**Types of Sclerenchyma (Stone) Cells.**—1. Typical sclerenchyma cells as they occur in the endocarp of drupaceous fruits and nuts. 2. Elongated bast-like sclerenchyma cells. 3. Thin-walled typical sclerenchyma cell. 4. Sclerenchyma cell with unequally thickened walls as they occur in the cinnamons. 5. Large thin-walled sclerenchyma cells as they occur in the seed coat of Amygdala. 6. Branching sclerenchyma cells as they occur in tea leaves and in peanut exocarp. 7, 8, 9. Forms of sclerenchyma cells.

FIG. 98.—**Typical Sclerenchyma Cells** (in groups) as they occur in the pulp of the pear.

(*f*) **Ice Creams.**—1. *Ice cream* is the frozen product, made from pure sweet milk or condensed milk or cream and sugar with or without a harmless flavoring or coloring, and contains not less than 10 per cent. of milk fat, and not more than six-tenths of 1 per cent. of pure and harmless vegetable gum or gelatin.

2. *Fruit ice cream* is the frozen product made from pure, sweet cream, sugar, and sound, clean, mature fruits, and contains not less than 8 per cent. of milk fat, and not more than six-tenths of 1 per cent. of pure and harmless vegetable gum or gelatin.

3. *Nut ice cream* is the frozen product made from pure, sweet cream, sugar, and sound, nonrancid nuts, and contains not less

than 8 per cent. of milk fat, and not more than six-tenths of 1 per cent. of pure and harmless vegetable gum or gelatin.

(*g*) **Miscellaneous Milk Products.**—1. *Whey* is the product remaining after the removal of fat and casein from milk in the process of cheese-making.

2. *Kumiss* is the product made by the alcoholic fermentation of mare's or cow's milk.

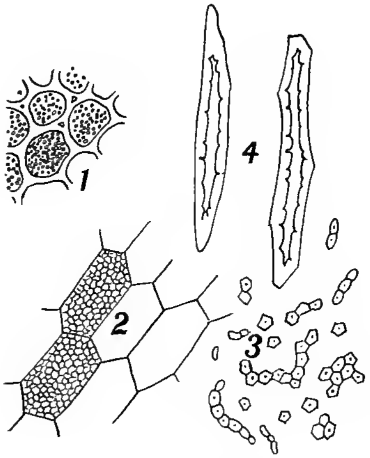

FIG. 99.

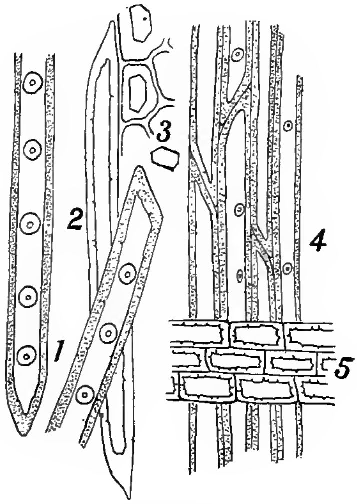

FIG. 100.

FIG. 99.—**Buckwheat.**—1. Proteid-bearing tissue. 2. Starch-bearing endosperm tissue. Cell walls are very thin and the entire cell lumen is packed with starch granules. 3. Starch granules. The granules resemble those of corn, being somewhat smaller. 4. Sclerenchymatous fibers.

Buckwheat is the predominating ingredient of the buckwheat pancake flours and is occasionally used as an adulterant of spices.

FIG. 100.—**Tissues of the Pine.**—1. The characteristic tracheids with bordered pits. 2. Bast-like fibers of the bark. 3. Crystal-bearing bark parenchyma cells. 4. Tracheids in radial view. 5. Medullary ray cells in radial view. Pine wood (pulp) is much used in making paper.

2. Vegetable Products

A. Grain Products

(*a*) **Grains and Meals.**—1. *Grain* is the fully matured, clean, sound, air-dry seed of wheat, maize, rice, oats, rye, buckwheat, barley, sorghum, millet, or spelt.

2. *Meal* is the clean, sound product made by grinding grain.

3. *Flour* is the fine, clean, sound product made by bolting wheat meal and contains not more than thirteen and one-half (13.5) per cent. of moisture, not less than one and twenty-five hundredths (1.25) per cent. of nitrogen, not more than one (1) per cent. of ash, and not more than fifty hundredths (0.50) per cent. of fiber.

4. *Graham flour* is unbolted wheat meal.

5. *Ground gluten* is the clean, sound product made from wheat flour by the almost complete removal of starch and contains not more than ten (10) per cent. of moisture, and, calculated on the water-free basis, not less than fourteen and two-tenths (14.2) per cent. of nitrogen, not more than fifteen (15) per cent. of nitrogen-free extract (using the protein factor 5.7), and not more than five and five-tenths (5.5) per cent. of starch (as determined by the diastase method).

6. *Gluten flour* is the clean, sound product made from wheat flour by the removal of a large part of the starch and contains not more than ten (10) per cent. of moisture, and, calculated on the water-free basis, not less than seven and one-tenth (7.1) per cent. of nitrogen, not more than fifty-six (56) per cent. of nitrogen-free extract (using the protein factor 5.7), and not more than forty-four (44) per cent. of starch (as determined by the diastase method).

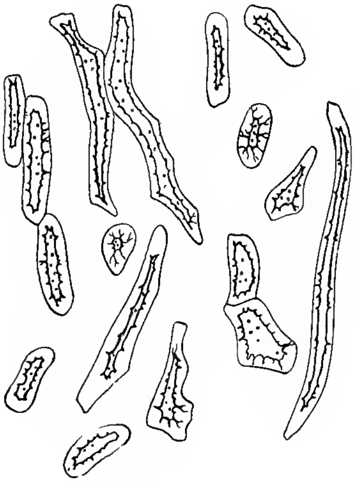

FIG. 101.

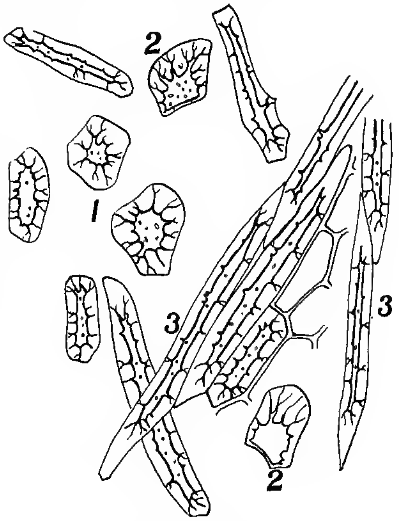

FIG. 102.

FIG. 101.—**Sclerenchymal Cells of Olive Pits.**—Ground olive pits were, until recently, extensively employed as an adulterant of spices and drugs.

FIG. 102.—**Clove Stems.**—A very common adulterant of cloves and of allspice. 1. Typical sclerenchyma cells. 2. Sclerenchyma cells with unequally thickened walls. 3. Sclerenchymatous bast fibers.

7. *Gluten flour, self-raising,* is a gluten flour containing not more than ten (10) per cent. of moisture, and leavening agents with or without salt.

8. *"Diabetic" food.* Although most foods may be suitable under certain conditions for the use of persons suffering from diabetes, the term "diabetic" as applied to food indicates a considerable lessening of the carbohydrates found in ordinary products of the same class,

and this belief is fostered by many manufacturers on their labels and in their advertising literature.

A "diabetic" food contains not more than half as much glycogenic carbohydrates as the normal food of the same class. Any statment on the label which gives the impression that any single food in unlimited quantity is suitable for the diabetic patient is false and misleading.

9. *Maize meal, corn meal, Indian corn meal,* is meal made from sound maize grain and contains not more than fourteen (14) per cent. of moisture, not less than one and twelve hundredths (1.12) per cent. of nitrogen, and not more than one and six-tenths (1.6) per cent. of ash.

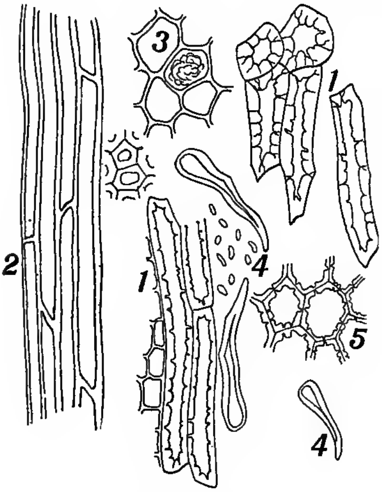

FIG. 103.

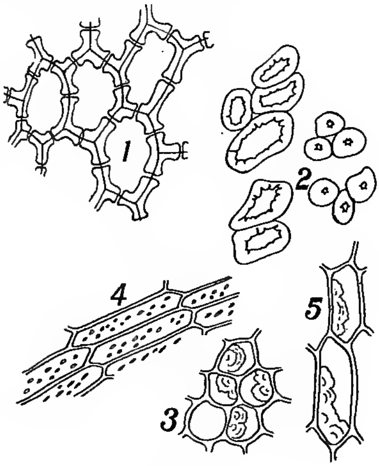

FIG. 104.

FIG. 103.—**Cassia Buds and Cassia Stems.**—1. Sclerenchymatous fibers of the cassia stems. 2. Bast fibers of cassia stems. Parenchymatous cells of the buds. 4. Trichomes of buds. 5. Thick-walled parenchyma cells. Cassia buds and cassia stems are frequently used in adulterating cloves, allspice and cinnamon.

FIG. 104.—**Coffee Adulterants.**—1. Sclerenchyma cells of date pits. 2. Sclerenchyma cells of the walnut shell. 3, 4, 5. Tracheids and inulin-bearing parenchyma cells of chicory. Figs and prunes are also much used as coffee adulterants, also cereals, fleshy roots, acorns, etc.

10. *Rice* is the hulled, or hulled and polished, grain of *Oryza sativa.*

11. *Oatmeal* is meal made from hulled oats and contains not more than twelve (12) per cent. of moisture, not more than one and five-tenths (1.5) per cent. of crude fiber, not less than two and twenty-four hundredths (2.24) per cent. of nitrogen, and not more than two and two-tenths (2.2) per cent. of ash.

12. *Rye flour* is the fine, clean, sound product made by bolting rye meal and contains not more than thirteen and one-half (13.5) per cent. of moisture, not less than one and thirty-six hundredths

(1.36) per cent. of nitrogen, and not more than one and twenty-five hundredths (1.25) per cent. of ash.

13. *Buckwheat flour* is bolted buckwheat meal and contains not more than twelve (12) per cent of moisture, not less than one and twenty-eight hundredths (1.28) per cent. of nitrogen, and not more than one and seventy-five hundredths (1.75) per cent. of ash.

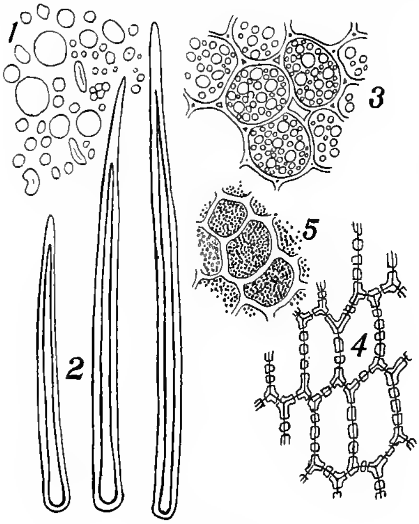

FIG. 105.

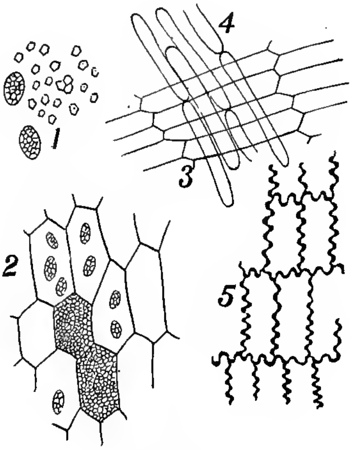

FIG. 106.

FIG. 105.—**Wheat Tissues.**—1. Wheat starch. 2. Trichomes from the bran. 3. Starch-bearing parenchyma. 4. Epicarp cells. 5. Proteid-bearing cells from middlings. Rye histology is similar to that of wheat. Wheat flour is used in macaroni, spaghetti, noodles, etc. Wheat flour, bran and middlings are much used for adulterating purposes. Rye starch differs from that of wheat in the larger size of the granules and the greater prominence of the hili.

FIG. 106.—**Rice Tissues.**—1. Starch. Single granules and aggregates. These aggregates are characteristic of rice and of oats. 2. Starch-bearing endosperm cells. 3, 4, 5. Epicarp and pericarp cells. In form the starch granules of rice, oat, corn, darnel, millet, fox-tail, buckwheat and chess resemble each other. The size varies very much.

B. Fruit and Vegetables

(Except fruit juices, fresh, sweet, and fermented, and vinegars.)

(*a*) **Fruit and Fruit Products.**—1. *Fruits* are the clean, sound, edible, fleshy fructifications of plants, distinguished by their sweet, acid, and ethereal flavors.

2. *Dried fruit*[1] is the clean, sound product made by drying mature, properly prepared, fresh fruit in such a way as to take up no harmful substance, and conforms in name to the fruit used in its preparation; *sun-dried fruit* is dried fruit made by drying without the use of artifical means; *evaporated fruit* is dried fruit made by drying with the use of artificial means.

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[1] The subject of sulphurous acid in dried fruits is reserved for consideration in connection with the schedule "Preservatives and Coloring Matters."

3. *Evaporated apples* are evaporated fruit made from peeled and cored apples, and contain not more than twenty-seven (27) per cent. of moisture determined by the usual commercial method of drying for four (4) hours at the temperature of boiling water.

(Standards for other dried fruits are in preparation.)

4. *Canned fruit* is the sound product made by sterilizing clean, sound, properly matured and prepared fresh fruit, by heating, with or without sugar (sucrose) and spices, and keeping in suitable, clean, hermetically sealed containers and conforms in name to the fruit used in its preparation.

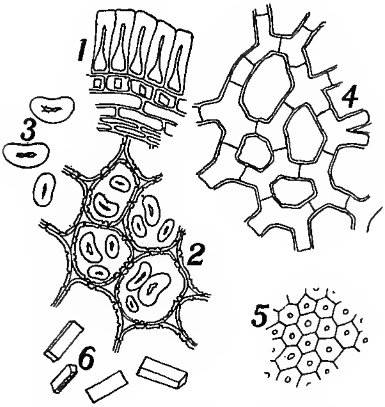

FIG. 107.

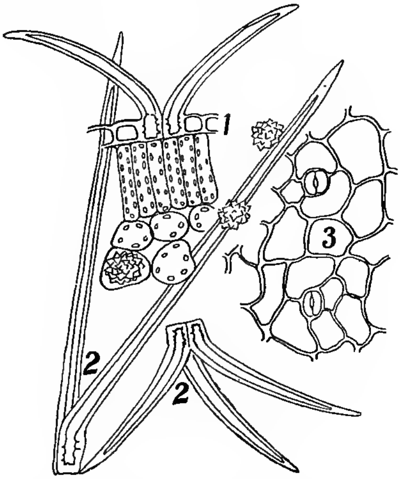

FIG. 108.

FIG. 107.—**Bean Tissues.**—1. Epidermal palisade tissue with the crystal-bearing hypoderm. 2. Starch-bearing endosperm tissue. 3. Starch granules with prominent fissured hili. 4. Spongy tissue. 5. Epidermal palisade cells in vertical view. 6. Prismatic crystals of calcium from hypoderm.

Ground beans, peas and lentils are used for adulterating purposes.

FIG. 108.—**Histology of Mallow Leaf.**—1. Transverse section of leaf showing stellate trichome, epidermal, palisade and spongy tissue cells. Aggregate crystals of calcium oxalate are present. 2. Stellate or aggregate trichomes. 3. Epidermal cells (lower) showing stomata. Mallow leaves are extensively employed for adulterating leafy spices and drugs.

5. *Preserve*[1] is the sound product made from clean, sound, properly matured and prepared fresh fruit and sugar (sucrose) sirup, with or without spices or vinegar, and conforms in name to that of the fruit used, and in its preparation not less than forty-five (45) pounds of fruit are used to each fifty-five (55) pounds of sugar.

6. *Honey preserve*[1] is preserve in which honey is used in place of sugar (sucrose) sirup.

7. *Glucose preserve*[1] is preserve in which a glucose product is used in place of sugar (sucrose) sirup.

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[1] The subject of sulphurous acid in dried fruits is reserved for consideration in connection with the schedule "Preservatives and Coloring Matters."

8. *Jam, marmalade,*[1] is the sound product made from clean, sound, properly matured and prepared fresh fruit and sugar (sucrose), with or without spices or vinegar, by boiling to a pulpy or semisolid consistence, and conforms in name to the fruit used, and in its preparation not less than forty-five (35) pounds of fruit are used to each fifty-five (55) pounds of sugar.

9. *Glucose jam, glucose marmalade,*[2] is jam in which a glucose product is used in place of sugar (sucrose).

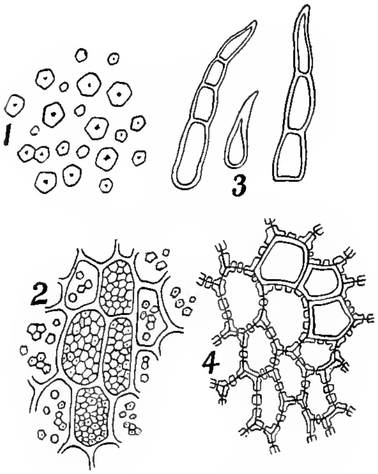

FIG. 109.

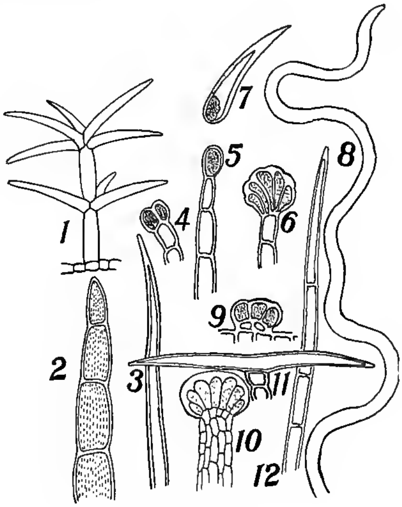

FIG. 110.

FIG. 109.—**Histology of Corn.**—1. Corn starch. 2. Starch-bearing endosperm of corn kernel. 3. Trichomes of the chaff of the corn cob. 4. Sclerenchymatous cells of the corn cob. Ground cobs are used for adulterating purposes and also in the manufacture of artificial maple syrup flavor.

FIG. 110.—**A Few Types of Trichomes.**—1. Branching trichome of mullein. 2. Many-celled simple trichome of henbane showing wart-like marking on outer surface. 3. Simple single-celled trichome as of rye and wheat. 4. Glandular trichome with two secreting cells. 5. Glandular trichome with one secreting cell. 6. Many-celled glandular trichome. 7. Simple, single-celled trichome of Indian hemp. 8. Much elongated and twisted single-celled trichome, as of sage. 9. Sessile glandular trichome (Eriodictyon). 10. Indian hemp. 11. Pyrethrum. 12. Simple trichome.

10. *Fruit butter*[2] is the sound product made from fruit juice and clean, sound, properly matured and prepared fruit, evaporated to a semisolid moss of homogeneous consistence, with or without the addition of sugar and spices or vinegar, and conforms in name to the fruit used in its preparation.

11. *Glucose fruit butter*[2] is fruit butter in which a glucose product is used in place of sugar (sucrose).

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[1] The subject of sulphurous acid in dried fruits is reserved for consideration in connection with the schedule "Preservatives and Coloring Matters."

[2] Products made with mixtures of sugar, glucose, honey, or any two thereof, are received for future consideration.

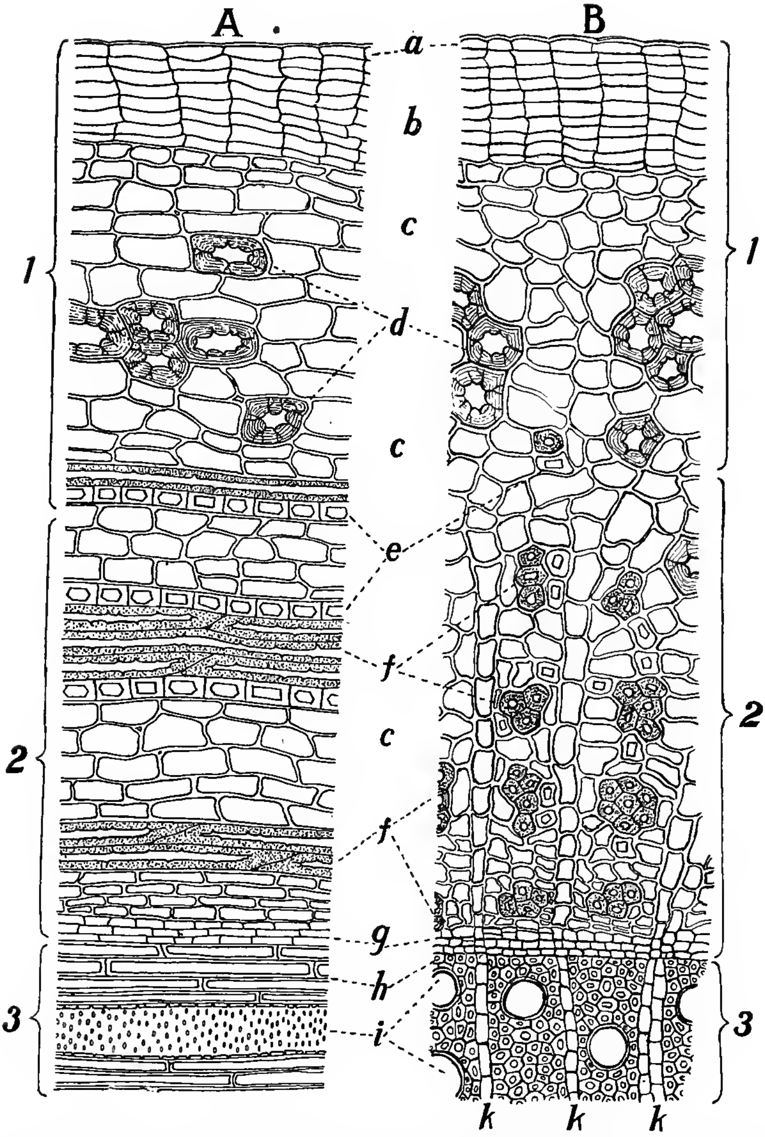

FIG. 111.—**Illustrating the Histology of a Typical Bark Showing all of the Tissues Which May be Found in a Bark.**—A, Longitudinal section in the radial direction but not showing the medullary rays. B, Transverse section. 1. Outer bark. The demarkation between outer and inner bark is not always distinct. 2. Inner bark. 3. Beginning of wood tissue. *a*, Epidermis. Always wanting in tree trunks and older branches. *b*, Cork tissue. *c*, Bark parenchyma. Cell-walls are usually not suberized and the cells may contain various inclusions such as crystals of calcium oxalate, tannin, starch granules and resin. *d*, Groups of sclerenchyma cells. These, when present, normally predominate in the outer bark. *e*, Crystal-bearing fibers which usually accompany the bast fibers. *f*, Bast fibers. These, when present, normally predominate in the inner bark. The fibers may occur singly or in groups. *g*, Cambium. *h*, Wood fibers. *i*, Ducts. Usually of the typically porous type. *k*, Medullary rays.

An excellent typical bark having all of the histological elements indicated in Plate VI is *Rhamnus purshiana*. The demarkation between outer bark and inner bark is well defined in Ulmus and Quillaja.

12. *Jelly*[1] is the sound, semisolid, gelatinous product made by boiling clean, sound, properly matured and prepared fresh fruit with water, concentrating the expressed and strained juice, to which sugar (sucrose) is added, and conforms in name to the fruit used in its preparation.

13. *Glucose jelly*[1] is jelly in which a glucose product is used in place of sugar (sucrose).

(*b*) **Vegetable and Vegetable Products.**—1. *Vegetables* are the succulent, clean, sound, edible parts of herbaceous plants used for culinary purposes.

2. *Dried vegetables* are the clean, sound products made by drying properly matured and prepared vegetables in such a way as to take up no harmful substance, and conform in name to the vegetables used in their preparation; *sun-dried vegetables* are dried vegetables made by drying without the use of artificial means; *evaporated vegetables* are dried vegetables made by drying with the use of artificial means.

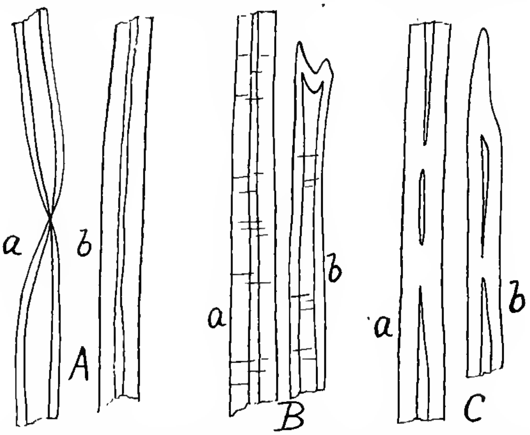

FIG. 112.—Vegetable fiber. A, cotton; *a*, ordinary cotton and *b*, mercerized cotton; B, hemp and C, jute.

3. *Canned vegetables* are sound, properly matured and prepared fresh vegetables, with or without salt, sterilized by heat, with or without previous cooking in vessels from which they take up no metallic substance, kept in suitable, clean, hermetically sealed containers, are sound and conform in name to the vegetables used in their preparation.

4. *Pickles* are clean, sound, immature cucumbers, properly prepared, without taking up any metallic compound other than salt, and preserved in any kind of vinegar, with or without spices; *pickled*

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[1] Products made with mixtures of sugar, glucose, and honey, or any two thereof, are received for future consideration.

onions, pickled beets, pickled beans, and other pickled vegetables are vegetables prepared as described above, and conform in name to the vegetables used.

5. *Salt pickles* are clean, sound, immature cucumbers, preserved in a solution of common salt, with or without spices.

6. *Sweet pickles* are pickled cucumbers or other vegetables in the preparation of which sugar (sucro is used).

7. *Sauerkraut* is clean, sound, properly prepared cabbage, mixed with salt, and subjected to fermentation.

8. *Catchup (ketchup, catsup)* is the clean, sound product made from the properly prepared pulp of clean, sound, fresh, ripe tomatoes, with spices and with or without sugar and vinegar; *mushroom catchup, walnut catchup, et cetera,* are catchups made as above described, and conform in name to the substances used in their preparation.

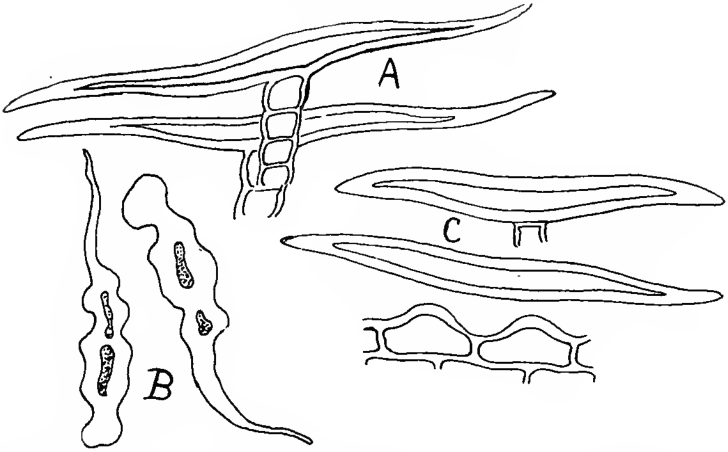

FIG. 113.—Diagnostic trichomes (hair cells). A, the T-shaped trichomes of absinthium (*Artemisia vulgaris*); B, two trichomes from the petal of capers (*Capparis spinosa*); C, T-shaped trichomes of the insect flower (*Pyrethrum roseum, P. Marshallii,* and *P. cinerariæfolium*). The stem or handle cells are usually removed in the powdered article.

C. Sugars and Related Substances

(*a*) **Sugar and Sugar Products.** *Sugars.*—1. *Sugar* is the product chemically known as sucrose (saccharose) chiefly obtained from sugar cane, sugar beets, sorghum, maple, and palm.

2. *Granulated, loaf, cut, milled, and powdered sugars* are different forms of sugar and contain at least ninety-nine and five-tenths (99.5) per cent. of sucrose.

3. *Maple sugar, maple concrete,* is the solid product resulting from the evaporation of maple sap or maple sirup.

4. *Massecuite*, *melada*, *mush sugar*, and *concrete* are products made by evaporating the purified juice of a sugar-producing plant, or a solution of sugar, to a solid or semisolid consistence, and in which the sugar chiefly exists in a crystalline state.

Molasses and Refiners' Sirup.—1. *Molasses* is the product left after separating the sugar from massecuite, melada, mush sugar, or concrete, and contains not more than twenty-five (25) per cent. of water and not more than five (5) per cent. of ash.

2. *Refiners' sirup, treacle*, is the residual liquid product obtained in the process of refining raw sugars and contains not more than twenty-five (25) per cent. of water and not more than eight (8) per cent. of ash.

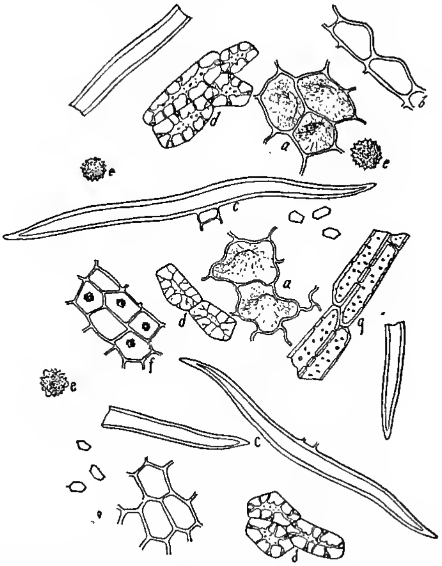

FIG. 114.—Insect powder (Pyrethrum species). Frequently adulterated with stems, old flowers, and flowers from foreign plants. *a*, Epidermal cells; *b*, epidermis, lateral view; *c*, trichomes; *d*, sclerenchyma; *e*, pollen grains; *f*, parenchyma with crystals; *g*, tracheids.

Sirups.—1. *Sirup* is the sound product made by purifying and evaporating the juice of a sugar-producing plant without removing any of the sugar.

2. *Sugar-cane sirup* is sirup made by the evaporation of the juice of the sugar-cane or by the solution of sugar-cane concrete, and contains not more than thirty (30) per cent. of water and not more than two and five-tenths (2.5) per cent. of ash.

3. *Sorghum sirup* is sirup made by the evaporation of sorghum juice or by the solution of sorghum concrete, and contains not more

than thirty (30) per cent. of water and not more than two and five-tenths (2.5) per cent. of ash.

4. *Maple sirup* is sirup made by the evaporation of maple sap or by the solution of maple concrete, and contains not more than thirty-five (35) per cent. of water and weighs not less than eleven (11) pounds to the gallon (231 cu. in.).

5. *Sugar sirup* is the product made by dissolving sugar to the consistence of a sirup and contains not more than thirty-five (35) per cent. of water.

(*b*) **Glucose Products.**—1. *Starch sugar* is the solid product made by hydrolyzing starch or a starch-containing substance until the greater part of the starch is converted into dextrose. Starch sugar appears in commerce in two forms, anhydrous starch sugar and hydrous starch sugar. The former, crystallized without water of crystallization, contains not less than ninety-five (95) per cent. of dextrose and not more than eight-tenths (0.8) per cent. of ash. The latter, crystallized with water of crystallization, is of two varieties—70 sugar, also known as brewer's sugar, contains not less than seventy (70) per cent. of dextrose and not more than eight-tenths (0.8) per cent. of ash; 80 sugar, climax or acme sugar, contains not less than eighty (80) per cent. of dextrose and not more than one and one-half (1.5) per cent. of ash.

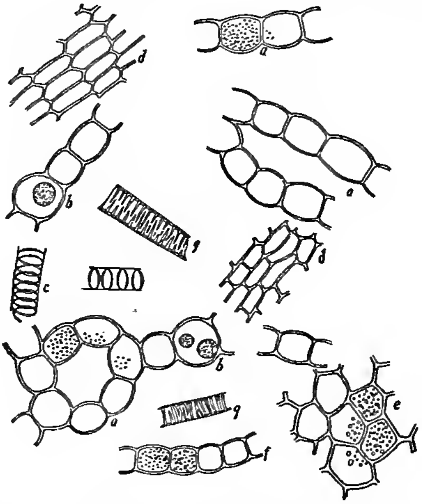

FIG. 115.—Calamus. *a*, Parenchyma with minute starch granules; *b*, oil and resin bearing cells; *c*, spiral duct; *d*, outer parenchyma and epidermis; *e*, parenchyma from near periphery; *f*, parenchyma as *a*; *g*, recticulate ducts.

The ash of all these products consists almost entirely of chlorids and sulphates.

2. *Glucose, mixing glucose, confectioner's glucose*, is a thick, sirupy, colorless product made by incompletely hydrolizing starch, or a starch-containing substance, and decolorizing and evaporating the product. It varies in density from forty-one (41) to forty-five (45) degrees Baumé at a temperature of 100°F. (37.7°C.), and conforms in density, within these limits, to the degree Baumé it is claimed to show, and for a density of forty-one (41) degrees Baumé contains not more than twenty-one (21) per cent. and for a density of forty-five (45) degrees not more than fourteen (14) per cent. of water. It contains on a basis of forty-one (41) degrees Baumé not more than one (1) per cent. of ash, consisting chiefly of chlorids and sulphates.

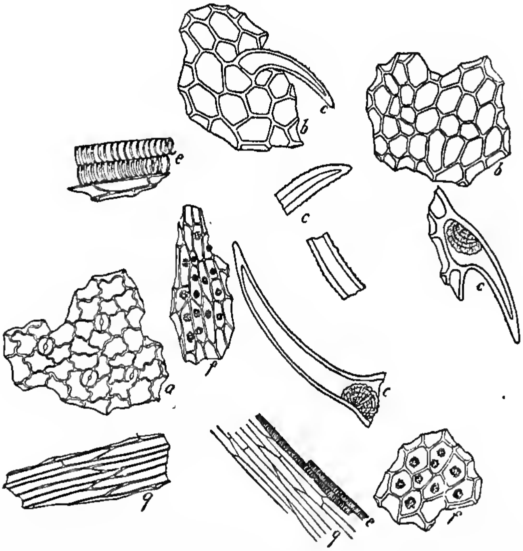

FIG. 116.—Indian hemp (*Canalüis satina*). *a*, Lower epidermis of leaves; *b*, upper epidermis of leaves; *c*, trichomes with cystoliths; *e*, spiral ducts; *f*, parenchyma with minute aggregate crystals; *g*, phlœm tissue.

(*c*) **Candy.**—1. *Candy* is a product made from a saccharine substance or substances with or without the addition of harmless coloring, flavoring, or filling materials and contains no terra alba, barytes, talc, chrome yellow, or other mineral substances or poisonous colors or flavors, or other ingredients deleterious or detrimental to health, or any vinous, malt, or spirituous liquor or compound, or narcotic drug.

(*d*) **Honey.**—1. *Honey* is the nectar and saccharine exudations of plants gathered, modified, and stored in the comb by honey bees (*Apis mellifica* and *A. dorsata*); is lævo-rotatory, contains not more than twenty-five (25) per cent. of water, not more than twenty-five hundredths (0.25) per cent. of ash, and not more than eight (8) per cent. of sucrose.

2. *Comb honey* is honey contained in the cells of comb.

3. *Extracted honey* is honey which has been separated from the uncrushed comb by centrifugal force or gravity.

4. *Strained honey* is honey removed from the crushed comb by straining or other means.

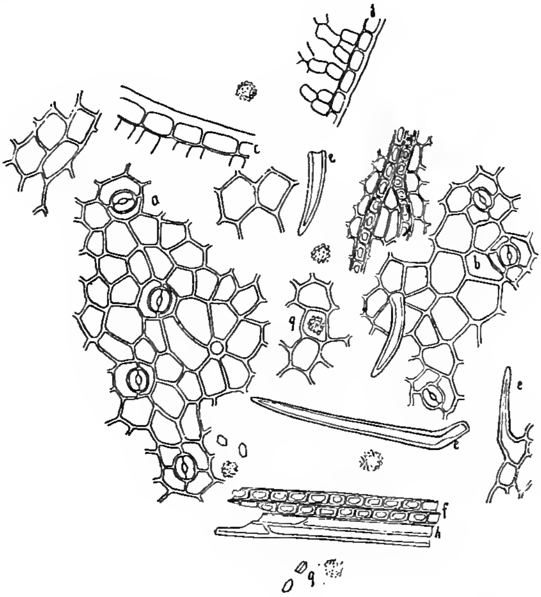

FIG. 117.—Senna leaf. *a*, Lower epidermis; *b*, upper epidermis; *c*, *d*, epidermis, lateral view; *e*, trichomes; *f*, crystal bearing fibres from vascular tissue; *g*, crystals; *h*, bast.

D. Condiments (except Vinegar and Salt)

(*a*) **Spices.**—1. *Spices* are aromatic vegetable substances used for the seasoning of food and from which no portion of any volatile oil or other flavoring principle has been removed and which are clean, sound, and true to name.

2. *Allspice*, *pimento*, is the dried fruit of the *Pimenta pimenta* (L.) Karst., and contains not less than eight (8) per cent. of quercitannic acid;[1] not more than six (6) per cent. of total ash, not more than five-tenths (0.5) per cent. of ash insoluble in hydrochloric acid, and not more than twenty-five (25) per cent. of crude fiber.

3. *Anise* is the fruit of the *Pimpinella anisum* L.

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[1] Calculated from the total oxygen absorbed by the aqueous extract.

4. *Bay leaf* is the dried leaf of *Laurus nobilis* L.

5. *Capers* are the flower buds of *Capparis spinosa* L.

6. *Caraway* is the fruit of *Carum carvi* L.

7. *Red pepper* is the red, dried, ripe fruit of any species of *Capsicum*.

8. *Cayenne pepper, cayenne*, is the dried ripe fruit of *Capsicum frutescens* L., *Capsicum baccatum* L., or some other small-fruited species of *Capsicum*, and contains not less than fifteen (15) per cent. of non-volatile ether extract; not more than six and five-tenths (6.5) per cent. of total ash; not more than five-tenths (0.5) per cent. of ash insoluble in hydrochloric acid; not more than one and five-tenths (1.5) per cent. of starch, and not more than twenty-eight (28) per cent. of crude fiber.

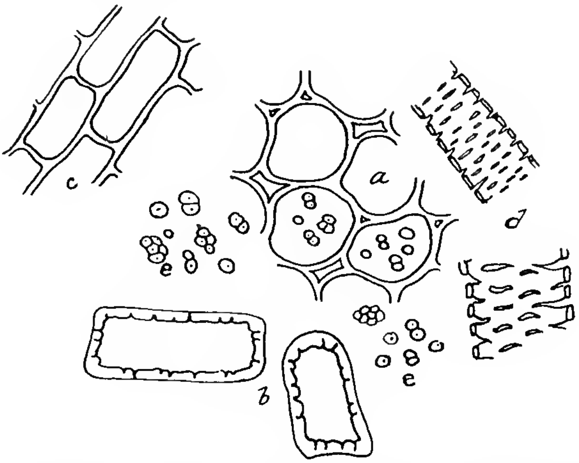

FIG. 118.—Aconite root (*Aconitum napellus L.*). *a* and *c*, starch bearing parenchyma cells; *b*, sclerenchyma cells found near the outer layers of the root parenchyma; *d*, tracheids. A highly poisonous medicinal plant which has been mistaken for horseradish.

9. *Paprika* is the dried ripe fruit of *Capsicum annuum* L., or some other large-fruited species of *Capsicum*, excluding seeds and stems.

10. *Celery seed* is the dried fruit of *Apium graveolens* L.

11. *Cinnamon* is the dried bark of any species of the genus *Cinnamomum* from which the outer layers may or may not have been removed.

12: *True cinnamon* is the dried inner bark of *Cinnamomum zeylanicum* Breyne.

13. *Cassia* is the dried bark of various species of *Cinnamomum*, other than *Cinnamomum zeylanicum*, from which the outer layers may or may not have been removed.

14. *Cassia buds* are the dried immature fruit of species of *Cinnamomum.*

15. *Ground cinnamon, ground cassia,* is a powder consisting of cinnamon, cassia, or cassia buds, or a mixture of these spices, and contains not more than six (6) per cent. of total ash and not more than two (2) per cent. of sand.

16. *Cloves* are the dried flowers of *Caryophyllus aromaticus* L., which contain not more than five (5) per cent. of clove stems; not less than ten (10) per cent. of volatile ether extract; not less than twelve (12) per cent. of quercitannir acid;[1] not more than eight (8) per cent. of total ash; not more than five-tenths (0.5) per cent. of ash insoluble in hydrochloric acid, and not more than ten (10) per cent. of crude fiber.

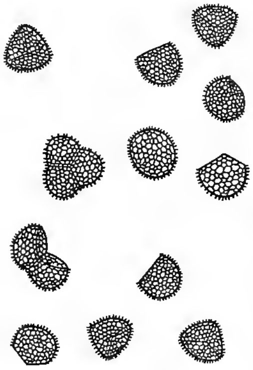

FIG. 119.

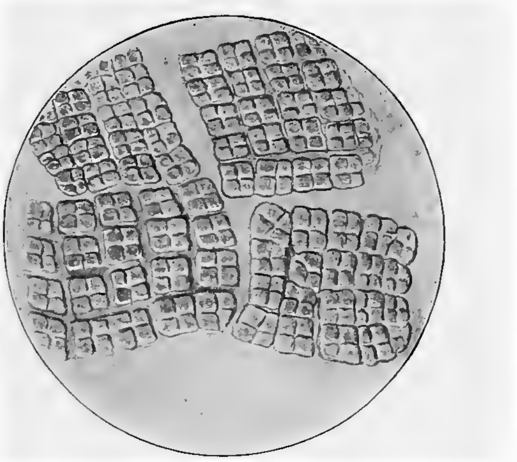

FIG. 120.

FIG. 119.—The spores of the club moss, a species of Lycopodium used in pharmaceutical practice and by the photographer in making flash light exposures. The novice is apt to confuse the spores of club mosses, true moss spores and the spores of some of the smuts and rusts. These structures have also been mistaken for the ovæ of intestinal parasites and of nematodes.

FIG. 120.—*Sarcina ventriculi.* The sarcinas are widely distributed in the air and in soils. They are quite commonly found in the intestinal tract of man as well as of lower animals, and is frequently causative of intestinal disturbances which are enzymatic in character.—(*McFarland after Migula.*)

17. *Coriander* is the dried fruit of *Coriandrum sativum* L.

18. *Cumin seed* is the fruit of *Cuminum cyminum* L.

19. *Dill seed* is the fruit of *Anethum graveolens* L.

20. *Fennel* is the fruit of *Foeniculum foeniculum* (L.) Karst.

21. *Ginger* is the washed and dried or decorticated and dried rhizome of *Zingiber zingiber* (L.) Karst., and contains not less than forty-two (42) per cent. of starch; not more than eight (8) per cent. of

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[1] Calculated from the total oxygen absorbed by the aqueous extract.

crude fiber, not more than six (6) per cent. of total ash, not more than one (1) per cent. of lime, and not more than three (3) per cent. of ash insoluble in hydrochloric acid.

FIGS. 120 to 131 inclusive.—Type of Fermentation Organisms. The following is an index to the organisms figured.

Aspergillus, 129, 130

Bacterium aceti, 121
B. Kützingianum, 121
B. Pasteurianum, 121
Bottom yeast, 124, 126

Mycoderma aceti, 121
M. vini, 122

Pseudo yeasts, 122

Saccharomyces anomalus, 123
S. cerevisiæ, 124, 126
S. ellipsoides, 124, 127
S. Pasteurianum, 123
S. pombe, 122
S. saké, 131
Saké (ferments), 129–131
Sarcina ventriculi, 120
Schizosaccharomyces, 123

Vinegar organisms, 121

Wine disease (slimy), 128

Torula, 122

Yeasts, bottom, 124, 126
Yeasts, top, 125
Yeasts, wild, 122

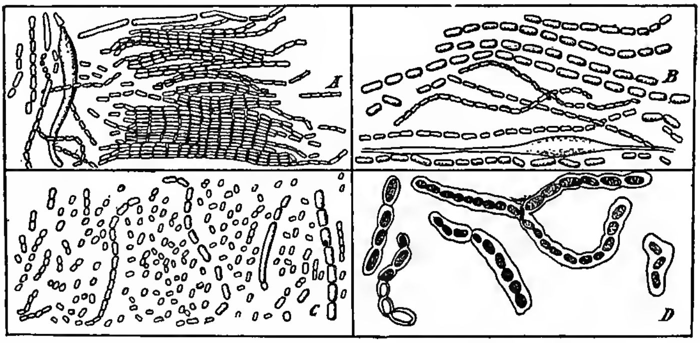

FIG. 121.—Vinegar organisms. *A*, *Bacterium* (*Mycoderma*) *aceti*; *B*, *Bacterium pasteurianum*; *C*. *Bacterium kützingianum*; *D*, *B*. *pasteurianum*, showing the mucilaginous sheath. This mucilaginous material causes the cells to stick together in large masses, forming the so-called "mother of vinegar."—(*Marshall*).

22. *Limed ginger*, *bleached ginger*, is whole ginger coated with carbonate of lime and contains not more than ten (10) per cent. of ash, not more than four (4) per cent. of carbonate of lime, and conforms in other respects to the standard for ginger.

23. *Horse-radish* is the root of *Roripa armoracia* (L.) Hitchcock, either by itself or ground and mixed with vinegar.

24. *Mace* is the dried arillus of *Myristica fragrans* Houttuyn, and contains not less than twenty (20) nor more than thirty (30) per cent. of nonvolatile ether extract, not more than three (3) per cent. of total ash, and not more than five-tenths (0.5) per cent. of ash insoluble in hydrochloric acid, and not more than ten (10) per cent. of crude fiber.

25. *Macassar mace*, *Papua mace*, is the dried arillus of *Myristica argentea* Warb.

26. *Bombay mace* is the dried arillus of *Myristica malabarica* Lamarck.

27. *Majoram* is the leaf, flower and branch of *Majorana majorana* (L.) Karst.

28. *Mustard seed* is the seed of *Sinapis alba* L. (white mustard), *Brassica nigra* (L.) Koch (black mustard), or *Brassica juncea* (L.) Cosson (black or brown mustard).

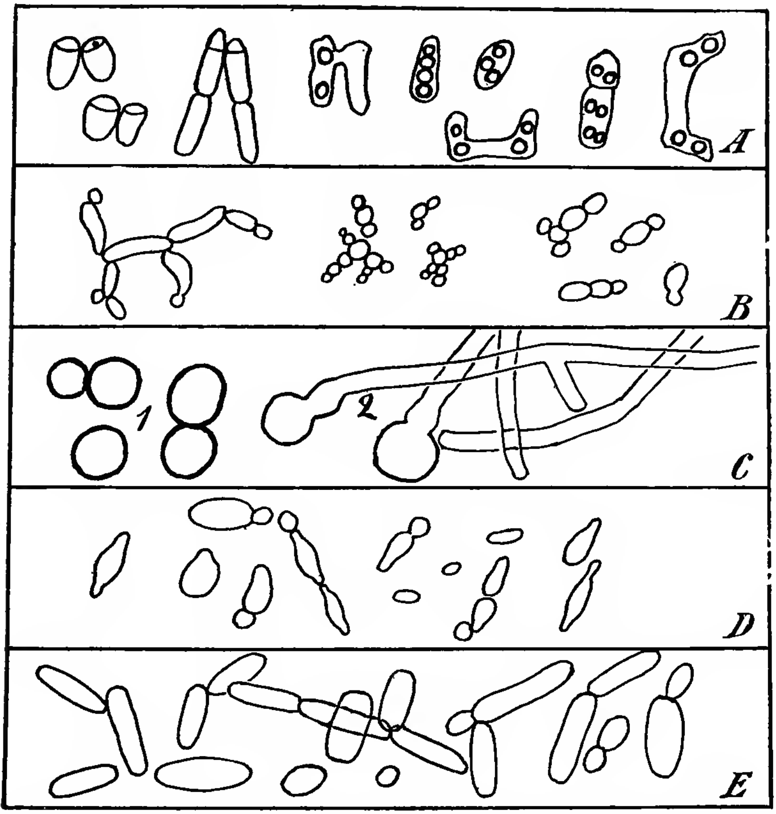

FIG. 122.—Wild and pseudo-yeasts. *A*, *S. pombe*. (*After Lindner*); *B*. *Torulæ*. (*After Pasteur*); *C*, *Mucor*, (1) spores; (2) germinating spores and mycelium; *D*, *S. apiculatus*; *E*. *Mycoderma vini*.—(*After Bioletti*.)

29. *Ground mustard* is a powder made from mustard seed, with or without the removal of the hulls and a portion of the fixed oil, and contains not more than two and five-tenths (2.5) per cent. of starch and not more than eight (8) per cent. of total ash.

30. *Prepared mustard, German mustard, French mustard, mustard paste*, is a paste composed of a mixture of gound mustard seed or mustard flour with salt, spices and vinegar, and, calculated free from

water, fat and salt, contains not more than twenty-four (24) per cent. of carbohydrates, calculated as starch, determined according to the official methods, not more than twelve (12) per cent. of crude fiber nor less than thirty-five (35) per cent. of protein, derived solely from the materials named.

31. *Nutmeg* is the dried seed of the *Myristica fragrans* Houttuyn, deprived of its testa, with or without a thin coating of lime, and contains not less than twenty-five (25) per cent. of nonvolatile ether extract, not more than five (5) per cent. of total ash, not more than five-tenths (0.5) per cent. of ash insoluble in hydrochloric acid, and not more than ten (10) per cent. of crude fiber.

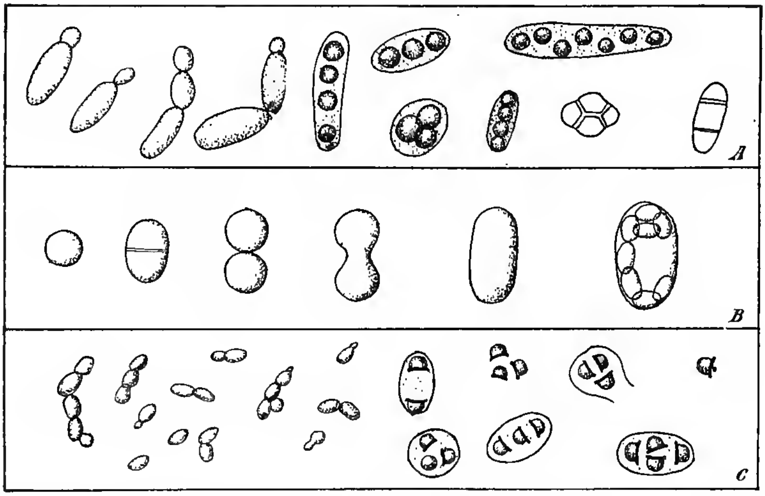

FIG. 123.—Types of yeast organisms and yeast sporulation. *A*, *Saccharomyces pasteurianus* showing spore formation in fours and eights (*after Bioletti*); *B*, *Schizosaccharomyces octosporus*, showing simple septation instead of budding, and spore formation (*after Schiönning*); *C*. *Saccharomyces anomalus*, vegetative cells and spore sacs.—(*Marshall, after Kayser.*)

32. *Macassar nutmeg, Papua nutmeg, male nutmeg, long nutmeg,* is the dried seed of *Myristica argentea* Warb., deprived of its testa.

33. *Black pepper* is the dried immature berry of *Piper nigrum* L. and contains not less than six (6) per cent. of nonvolatile ether extract, not less than twenty-five (25) per cent. of starch, not more than seven (7) per cent. of total ash, not more than two (2) per cent. of ash insoluble in hydrochloric acid, and not more than fifteen (15) per cent. of crude fiber. One hundred parts of the nonvolatile ether extract contain not less than three and one-quarter (3.25) parts of nitrogen. *Ground black pepper* is the product made by grinding the entire berry and contains the several parts of the berry in their normal proportions.

34. *Long pepper* is the dried fruit of *Piper longum* L.

35. *White pepper* is the dried mature berry of *Piper nigrum* L. from which the outer coating or the outer and inner coatings have been removed and contains not less than six (6) per cent. of non-volatile ether extract, not less than fifty (50) per cent. of starch, not more than four (4) per cent. of total ash, not more than five-tenths (0.5) per cent. of ash insoluble in hydrochloric acid, and not more than five (5) per cent. of crude fiber. One hundred parts, of the non-volatile ether extract contain not less than four (4) parts of nitrogen.

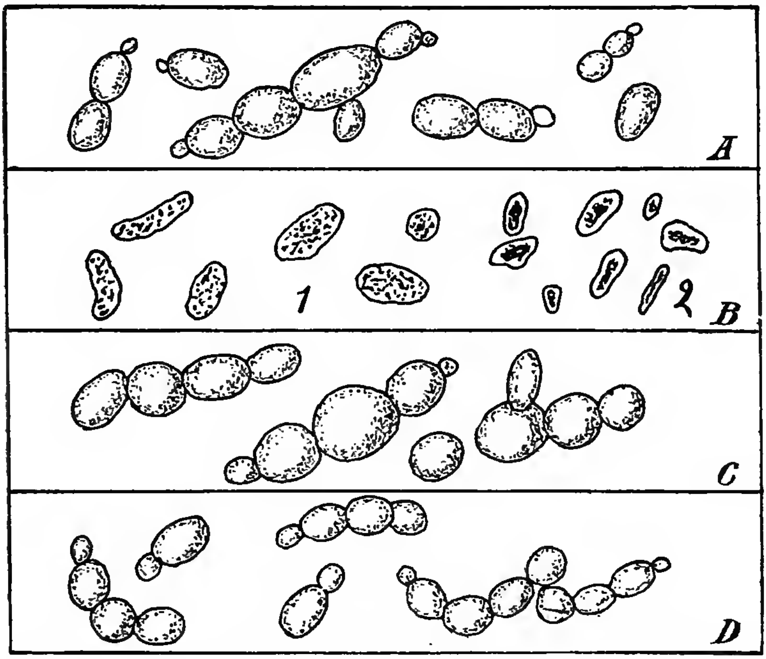

FIG. 124.—Wine and beer yeasts. *A*, *Saccharomyces ellipsoides* showing the young and vigorous cells; *B*, the same cells old (1) and dead (2); *C*, *S. cerevisea* as top yeast and *D*, *S. cerevisea* as bottom yeast.—(*Marshall.*)

36. *Saffron* is the dried stigma of *Crocus sativus* L.

37. *Sage* is the leaf of *Salvia officinalis* L.

38. *Savory, summer savory*, is the leaf, blossom, and branch of *Satureja hortensis* L.

39. *Thyme* is the leaf and tip of blooming branches of *Thymus vulgaris* L.

(*b*) **Flavoring Extracts.**—1. A *flavoring extract*[1] is a solution in ethyl of alcohol of proper strength of the sapid and odorous principles

[1] The flavoring extracts herein described are intended solely for food purposes and are not to be confounded with similar preparations described in the Pharmacopœia for medicinal purposes.

derived from an aromatic plant, or parts of the plant, with or without its coloring matter, and conforms in name to the plant used in its preparation.

2. *Almond extract* is the flavoring extract prepared from oil of bitter almonds, free from hydrocyanic acid, and contains not less than one (1) per cent. by volume of oil of bitter almonds.

2*a*. *Oil of bitter almonds*, commercial, is the volatile oil obtained from the seed of the bitter almond (*Amygdalus communis* L.), the apricot (*Prunus armeniaca* L.), or the peach (*Amygdalus persica* L.).

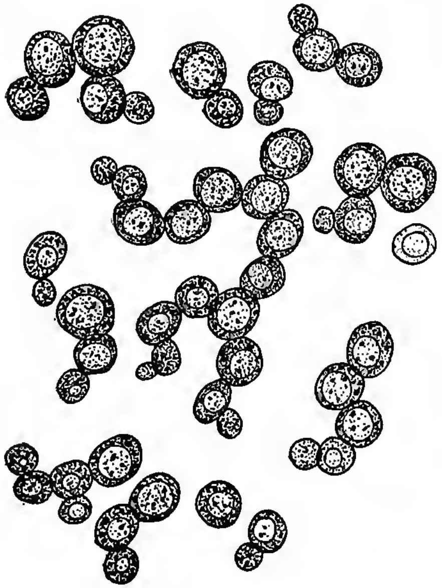

FIG. 125.—*Saccharomyces cerevisеæ.* The variety known as brewers' top yeast.—(*Oberhefe.*)

3. *Anise extract* is the flavoring extract prepared from oil of anise, and contains not less than three (3) per cent. by volume of oil of anise.

3*a*. *Oil of anise* is the volatile oil obtained from the anise seed.

4. *Celery seed extract* is the flavoring extract prepared from celery seed or the oil of celery seed, or both, and contains not less than three-tenths (0.3) per cent. by volume of oil of celery seed.

4*a*. *Oil of celery seed* is the volatile oil obtained from celery seed.

5. *Cassia extract* is the flavoring extract prepared from oil of cassia and contains not less than two (2) per cent. by volume of oil of cassia.

5*a*. *Oil of Cassia* is the lead-free volatile oil obtained from the leaves or bark of *Cinnamomum cassia* Bl., and contains not less than seventy-five (75) per cent. by weight of cinnamic aldehyde.

6. *Cinnamon extract* is the flavoring extract prepared from oil of cinnamon, and contains not less than two (2) per cent. by volume of oil of cinnamon.

6*a*. *Oil of cinnamon* is the lead-free volatile oil obtained from the bark of the Ceylon cinnamon (*Cinnamomun zeylanicum* Breyne), and contains not less than sixty-five (65) per cent. by weight of cinnamic aldehyde and not more than ten (10) per cent. by weight of eugenol.

7. *Clove extract* is the flavoring extract prepared from oil of cloves, and contains not less than two (2) per cent. by volume of oil of cloves.

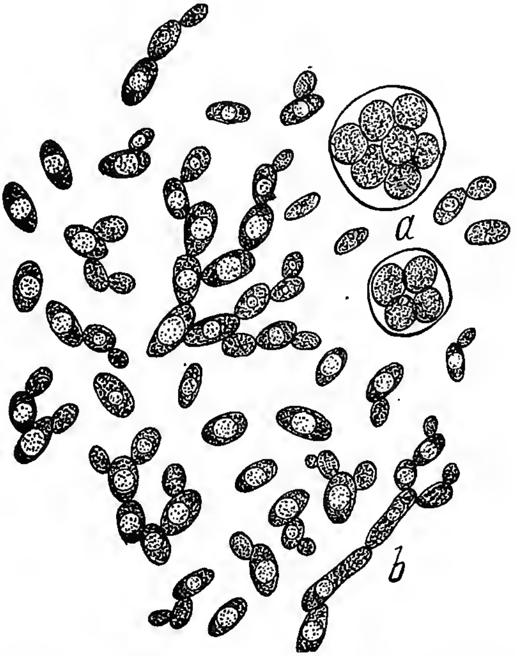

FIG. 126.—*Saccharomyces cerevisece.* The variety known as brewers' bottom yeast (*Unterhefe*). *a*, Spore formation; *b*, elongated cells (rudimentary filaments or hyphæ).

7*a*. *Oil of cloves* is the lead-free, volatile oil obtained from cloves.

8. *Ginger extract* is the flavoring extract prepared from ginger and contains in each one hundred (100) cubic centimeters, the alcohol-soluble matters from not less than twenty (20) grams of ginger.

9. *Lemon extract* is the flavoring extract prepared from oil of lemon, or from lemon peel, or both, and contains not less than five (5) per cent. by volume of oil of lemon.

9*a*. *Oil of lemon* is the volatile oil obtained, by expression or alcoholic solution, from the fresh peel of the lemon (*Citrus limonum*

L.) has an optical rotation (25°C.) of not less than +60° in a 100-millimeter tube, and contains not less than four (4) per cent. by weight of citral.

10. *Terpeneless extract of lemon* is the flavoring extract prepared by shaking oil of lemon with dilute alcohol, or by dissolving terpeneless oil of lemon in dilute alcohol, and contains not less than two-tenths (0.2) per cent. by weight of citral derived from oil of lemon.

10*a*. *Terpeneless oil of lemon* is oil of lemon from which all or nearly all of the terpenes have been removed.

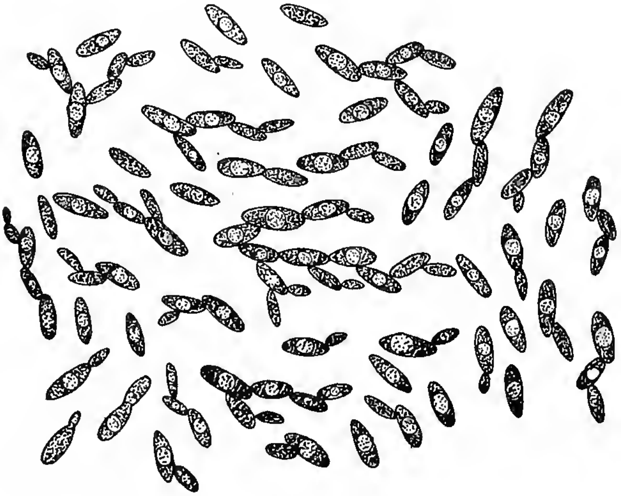

FIG. 127.—*Saccharomyces ellipsoides.* The common wine ferment. Also common in jams, jellies and canned fruits.

11. *Nutmeg extract* is the flavoring extract prepared from oil of nutmeg, and contains not less than two (2) per cent. by volume of oil of nutmeg.

11*a*. *Oil of nutmeg* is the volatile oil obtained from nutmegs.

12. *Orange extract* is the flavoring extract prepared from oil of orange, or from orange peel, or both, and contains not less than five (5) per cent. by volume of oil of orange.

12*a*. *Oil of orange* is the volatile oil obtained, by expression or alcoholic solution, from the fresh peel of the orange (*Citrus aurantium* L.) and has an optical rotation (25°C.) of not less than +95° in a 100-millimeter tube.

13. *Terpeneless extract of orange* is the flavoring extract prepared by shaking oil of orange with dilute alcohol, or by dissolving terpeneless oil of orange in dilute alcohol, and corresponds in flavoring strength to orange extract.

13*a*. *Terpeneless oil of orange* is oil of orange from which all or nearly all of the terpenes have been removed.

14. *Peppermint extract* is the flavoring extract prepared from oil of peppermint, or from peppermint, or both, and contains not less than three (3) per cent. by volume of oil of peppermint.

14*a*. *Peppermint* is the leaves and flowering tops of *Mentha piperita* L.

14*b*. *Oil of peppermint* is the volatile oil obtained from peppermint and contains not less than fifty (50) per cent. by weight of menthol.

15. *Rose extract* is the flavoring extract prepared from otto of roses, with or without red rose petals, and contains not less than four-tenths (0.4) per cent. by volume of otto of roses.

15*a*. *Otto of roses* is the volatile oil obtained from the petals of *Rosa damascena* Mill., *R. centifolia* L., or *R. mosehata* Herrm.

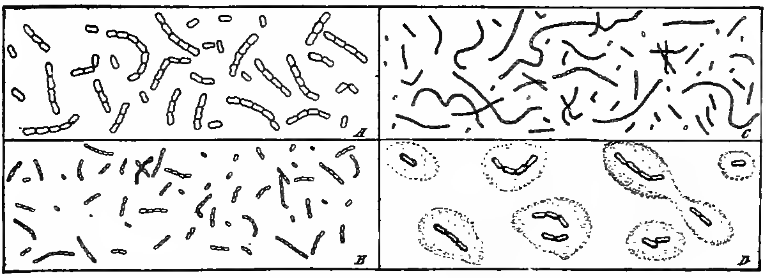

FIG. 128.—Bacteria of slimy wine. *A*, *B*, *C*, pure cultures of various forms; *D*, mucilaginous sheath of slime bacteria. (*After Kayser and Manceau.*)

16. *Savory extract* is the flavoring extract prepared from oil of savory, or from savory, or both, and contains not less than thirty-five hundredths (0.35) per cent. by volume of oil of savory.

16*a*. *Oil of savory* is the volatile oil obtained from savory.

17. *Spearmint extract* is the flavoring extract prepared from oil of spearmint, or from spearmint, or both, and contains not less than three (3) per cent. by volume of oil of spearmint.

17*a*. *Spearmint* is the leaves and flowering tops of *Mentha spicata* L.

17*b*. *Oil of spearmint* is the volatile oil obtained from spearmint.

18. *Star anise extract* is the flavoring extract prepared from oil of star anise, and contains not less than three (3) per cent. by volume of oil of star anise.

18*a*. *Oil of star anise* is the volatile oil distilled from the fruit of the star anise (*Illicium verum* Hook).

19. *Sweet basil extract* is the flavoring extract prepared from oil of sweet basil, or from sweet basil, or both, and contains not less than one-tenth (0.1) per cent. by volume of oil of sweet basil.

19*a*. *Sweet basil, basil,* is the leaves and tops of *Ocymum basilicum* L.

19*b*. *Oil of sweet basil* is the volatile oil obtained from basil.

20. *Sweet marjoram extract, marjoram extract,* is the flavoring extract prepared from the oil of marjoram, or from marjoram, or both, and contains not less than one (1) per cent. by volume of oil of marjoram.

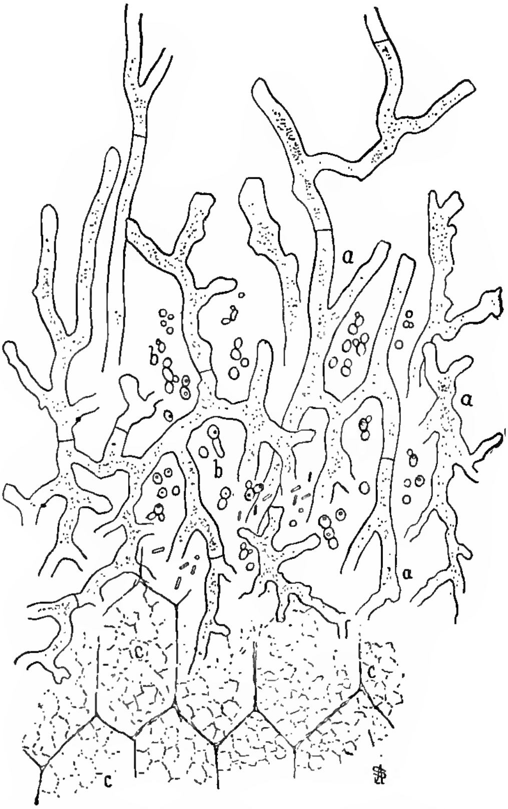

FIG. 129.—Saké. Steamed rice cells (*c*) attacked by the fungus (*Aspergillus oryzæ*). The fungus changes the starch into saccharine substances. Yeasts and bacteria are usually associated with the hyphal fungus, feeding upon the saccharine substances formed.

20*a*. *Oil of marjoram* is the volatile oil obtained from marjoram.

21. *Thyme extract* is the flavoring extract prepared from oil of thyme, or from thyme, or both, and contains not less than two-tenths (0.2) per cent. by volume of oil of thyme.

21*a*. *Oil of thyme* is the volatile oil obtained from thyme.

22. *Tonka extract* is the flavoring extract prepared from tonka bean, with or without sugar or glycerin, and contains not less than

one-tenth (0.1) per cent. by weight of coumarin extracted from the tonka bean, together with a corresponding proportion of the other soluble matters thereof.

22*a*. *Tonka bean* is the seed of *Coumarouna odorata* Aublet (*Dipteryx odorata* (Aubl.) (Willd.).

23. *Vanilla extract* is the flavoring extract prepared from vanilla bean, with or without sugar or glycerin, and contains in one hundred (100) cubic centimeters the soluble matters from not less than ten (10) grams of the vanilla bean.

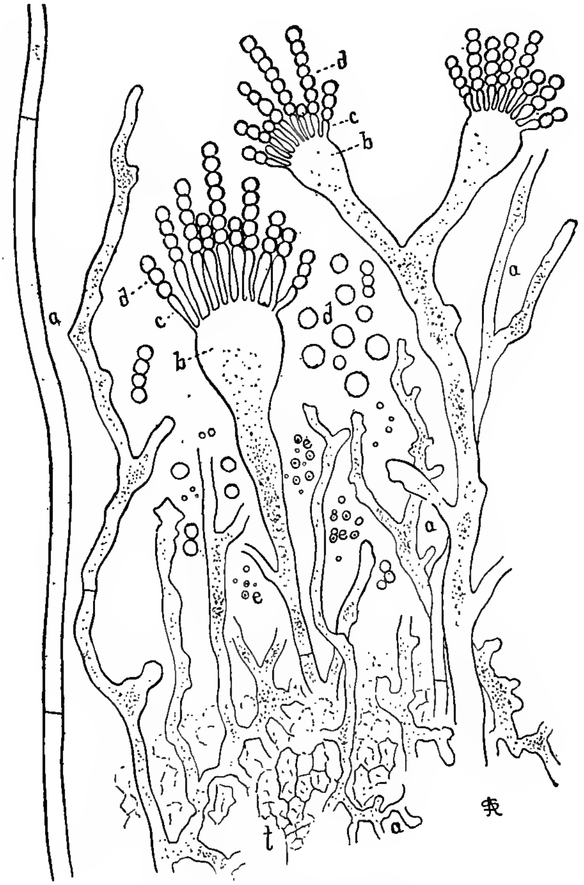

FIG. 130.—Saké. *Aspergillus oryzæ*, showing vegetative hyphæ (*a*) and the spore-forming hyphæ (*b*, *c*, *d*).

23*a*. *Vanilla bean* is the dried, cured fruit of *Vanilla planifolia* Andrews.

24. *Wintergreen extract* is the flavoring extract prepared from oil of wintergreen, and contains not less than three (3) per cent. by volume of oil of wintergreen.

24*a*. *Oil of wintergreen* is the volatile oil distilled from the leaves of the *Gaultheria procumbens* L.

(*c*) **Edible Vegetable Oils and Fats.**—1. *Olive oil* is the oil obtained from the sound, mature fruit of the cultivated olive tree (*Olea europoea* L.) and subjected to the usual refining processes; is free from rancidity; has a refractive index (25°C.) not less than one and forty-six hundred and sixty ten-thousandths (1.4660) and not exceeding one and forty-six hundred and eighty ten-thousandths (1.4680); and an iodin number not less than seventy-nine (79) and not exceeding ninety (90).

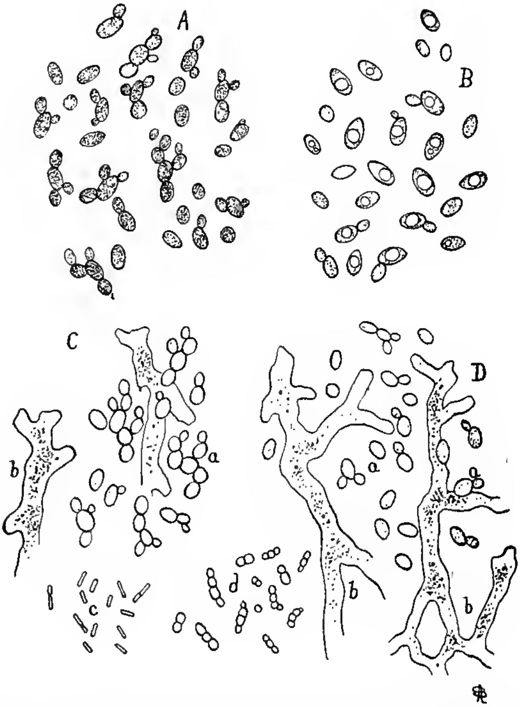

FIG. 131.—Saké. *A*, Dead or dying yeast cells (*Saccharomyces saké*). Vacuoles are wanting, the cell walls are generally more thickened and the cells are somewhat shrunken in appearance; *B*, living yeast cells showing distinct vacuoles; *C*, *D*, actively budding yeast cells (*S. saké*) and hyphæ of aspergillus from the fermenting vats.

2. *Virgin olive oil* is olive oil obtained from the first pressing of carefully selected, hand-picked olives.

3. *Cotton-seed oil* is the oil obtained from the seeds of cotton plants (*Gossypium hirsutum* L., G. *barbadense* L., or *G. herbaceum* L.) and subjected to the usual refining processes; is free from rancidity, has a refractive index (25°C). not less than one and forty-seven hundred ten-thousandths (1.4700) and not exceeding one and forty-seven hundred and twenty-five ten-thousandths (1.4725); and an iodin

number not less than one hundred and four (104) and not exceeding one hundred and ten (110).

4. *"Winter-yellow" cotton-seed oil* is expressed cotton-seed oil from which a portion of the stearin has been separated by chilling and pressure, and has an iodin number not less than one hundred and ten (110) and not exceeding one hundred and sixteen (116).

5. *Peanut oil, arachis oil, earth nut oil,* is the oil obtained from the peanut (*Arachis hypogaea* L.) and subjected to the usual refining processes; is free from rancidity; has a refractive index (25°C). not less than one and forty-six hundred and ninety ten-thousandths (1.4690) and not exceeding one and forty-seven hundred and seven ten-thousandths (1.4707); and an iodin number not less than eighty-seven (87) and not exceeding one hundred (100).

6. *"Cold-drawn" peanut oil*[1] is peanut oil obtained by pressure without heating.

7. *Sesame oil, gingili oil, teel oil,* is the oil obtained from the seeds of the sesame plants (*Sesamum orientale* L. and *S. radiatum* Schum. and Thonn.) and subjected to the usual refining processes; is free from rancidity; has a refractive index (25°C.) not less than one and forty-seven hundred and four ten-thousandths (1.4704) and not exceeding one and forty-seven hundred and seventeen ten-thousandths (1.4717); and an iodin number not less than one hundred and three (103) and not exceeding one hundred and twelve (112).

8. *"Cold-drawn" sesame oil*[1] is sesame oil obtained by pressure without heating.

9. *Poppy-seed oil*[1] is the oil obtained from the seed of the poppy (*Papaver somniferum* L.) subjected to the usual refining processes and free from rancidity.

10. *White poppy-seed oil, "cold-drawn" poppy-seed oil*[1] is poppy-seed oil of the first pressing without heating.

11. *Cocoanut oil*[1] is the oil obtained from the cocoanut (*Cocos nucifera* L.) and subjected to the usual refining processes and free from rancidity.

12. *Cochin oil* is cocoanut oil prepared in Cochin (Malabar).

13. *Ceylon oil* is cocoanut oil prepared in Ceylon.

14. *Copra oil* is cocoanut oil prepared from copra, the dried meat of the cocoanut.

15. *Rape-seed oil, colza oil,*[1] is the oil obtained from the seeds of the rape plant (*Brassica napus* L.) and subjected to the usual refining processes and free from rancidity.

16. *"Cold-drawn" rape-seed oil*[1] is rape-seed oil obtained by the first pressing without heating.

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[1] The fixing of limits for chemical and physical properties is reserved for future consideration.

17. *Sunflower oil*[1] is the oil obtained from the seeds of the sunflower (*Helianthus annuus* L.) and subjected to the usual refining processes and free from rancidity.

18. "*Cold-drawn*" *sunflower oil*[1] is sunflower oil obtained by the first pressing without heating.

19. *Maize oil, corn oil*,[1] is the oil obtained from the germ of the maize (*Zea mays* L.) and subjected to the usual refining processes and free from rancidity.

20. *Cocoa butter, cacao butter*, is the fat obtained from roasted, sound cocoa beans (*Theobroma cacao* L.) and subjected to the usual refining processes; is free from rancidity; has a refractive index (40°C.) not less than one and forty-five hundred and sixty-six ten-thousandths (1.4566) and not exceeding one and forty-five hundred and ninty-eight ten-thousandths (1.4598), an iodin number not less than thirty-three (33) and not exceeding thirty-eight (38); and a melting point not lower than 30°C. nor higher than 35°C.

21. *Cotton-seed oil stearin* is the solid product made by chilling cottonseed oil and separating the solid portion by filtration, with or without pressure, and having an iodin number not less than eighty-five (85) and not more than one hundred (100).

E. Tea, Coffee, and Cocoa Products

(*a*) **Tea.**—1. *Tea* is the leaves and leaf buds of different species of *Thea*, prepared by the usual trade processes of fermenting, drying, and firing; meets the provisions of the act of Congress approved March 2, 1897, and the regulations made in conformity therewith (Treasury Department Circular 16, February 6, 1905); conforms in variety and place of production to the name it bears; and contains not less than four (4) nor more than seven (7) per cent. of ash.

(*b*) **Coffee.**—1. *Coffee* is the seed of *Coffea arabica* L. or *Coffea liberica* Bull., freed from all but a small portion of its spermoderm, and conforms in variety and place of production to the name it bears.

2. *Roasted coffee* is coffee which by the action of heat has become brown and developed its characteristic aroma, and contains not less than ten (10) per cent. of fat and not less than three (3) per cent. of ash.

(*c*) **Cocoa and Cocoa Products.**—1. *Cocoa beans* are the seeds of the cacao tree, *Theobroma cacao* L.

2. *Cocoa nibs, cracked cocoa*, is the roasted, broken cocoa bean freed from its shell or husk.

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[1] The fixing of limits for chemical and physical properties is reserved for future consideration.

3. *Chocolate, plain chocolate, bitter chocolate, chocolate liquor, chocolate paste, bitter chocolate coatings,* is the solid or plastic mass obtained by grinding cocoa nibs without the removal of fat or other constituents except the germ, and contains not more than three (3) per cent. of ash insoluble in water, three and fifty hundredths (3.50) per cent. of crude fiber, and nine (9) per cent. of cocoa starch, and not less than forty-five (45) per cent. of cocoa fat.

4. *Sweet chocolate, sweet chocolate coatings,* is chocolate mixed with sugar (sucrose), with or without the addition of cocoa butter, spices or other flavoring materials, and contains in the sugar- and fat-free residue no higher percentage of either ash, fiber, or starch than is found in the sugar- and fat-free residue of chocolate.

5. *Cocoa, powdered cocoa,* is cocoa nibs, with or without the germ, deprived of a portion of its fat and finely pulverized, and contains percentages of ash, crude fiber and starch corresponding to those in chocolate after correction for fat removed.

6. *Sweet cocoa, sweetened cocoa,* is cocoa mixed with sugar (sucrose), and contains not more than sixty (60) per cent. of sugar (sucrose), and in the sugar- and fat-free residue no higher percentage of either ash, crude fiber, or starch than is found in the sugar and fat-free residue of chocolate.

7. *Milk chocolate, milk cocoa, sweet milk chocolate or sweet milk cocoa,* respectively, is chocolate, cocoa, sweet chocolate or sweet cocoa which contains not less than twelve (12) per cent. of whole milk solids in the finished product.

F. Beverages

(*a*) **Fermented Fruit Juices.**—1. *Wine* is the product made by the normal alcoholic fermentation of the juice of sound, ripe grapes, and the usual cellar treatment,[1] and contains not less than seven (7) nor more than sixteen (16) per cent. of alcohol, by volum, and, in one hundred (100) cubic centimeters (20°C.), not more than one-tenth (0.1) gram of sodium chlorid nor more than two-tenths (0.2) gram of potassium sulphate; and for red wine not more than fourteen hundredths (0.14) gram, and for white wine not more than twelve hundredths (0.12) gram of volatile acids produced by fermentation and calculated as acetic acid. *Red wine* is wine containing the red coloring matter of the skins of grapes. *White wine* is wine made from white grapes or the expressed fresh juice of other grapes.

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[1] The subject of sulphurous acid in wine is reserved for consideration in connection with the scedule, "Preservatives and Coloring Matters."

2. *Dry wine* is wine in which the fermentation of the sugars is practically complete and which contains, in one hundred (100) cubic centimeters (20°C.) less than one (1) gram of sugars and for dry red wine not less than sixteen hundredths (0.16) gram of grape ash and not less than one and six-tenths (1.6) grams of sugar-free grape solids, and for dry white wine not less than thirteen hundredths (0.13) gram of grape ash and not less than one and four-tenths (1.4) grams of sugar-free grape solids.

3. *Fortified dry wine* is dry wine to which brandy has been added but which conforms in all other particulars to the standard of dry wine.

4. *Sweet wine* is wine in which the alcoholic fermentation has been arrested, and which contains, in one hundred (100) cubic centimeters (20°C.) not less than one (1) gram of sugars, and for sweet red wine not less than sixteen hundredths (0.16) gram of grape ash, and for sweet white wine not less than thirteen hundredths (0.13) gram of grape ash.

5. *Fortified sweet wine* is sweet wine to which wine spirits have been added. By act of congress, "sweet wine" used for making fortified sweet wine and "wine spirits" used for such fortification are defined as follows (Sec. 43, act of October 1, 1890, 26 Stat., 567, as amended by section 68, act of August 27, 1894, 28 Stat., 509, and further amended by act of congress approved June 7, 1906): "That the wine spirits mentioned in section 42 of this act is the product resulting from the distillation of fermented grape juice to which water may have been added prior to, during, or after fermentation, for the sole purpose of facilitating the fermentation and economical distillation thereof, and shall be held to include the products from grapes or their residues, commonly known as grape brandy; and the pure sweet wine, which may be fortified free of tax, as provided in said section, is fermented grape juice only, and shall contain no other substance whatever introduced before, at the time of, or after fermentation, except as herein expressly provided; and such sweet wine shall contain not less than four per centum of saccharine matter, which saccharine strength may be determined by testing with Balling's saccharometer or must scale, such sweet wine, after the evaporation of the spirits contained therein, and restoring the sample tested to original volume by addition of water; *provided*, that the addition of pure boiled or condensed grape must or pure crystallized cane or beet sugar or pure anhydrous sugar to the pure grape juice aforesaid, or the fermented product of such grape juice prior to the fortification provided by this act for the sole purpose of perfecting sweet

wine according to commercial standard, or the addition of water in such quantities only as may be necessary in the mechanical operation of grape conveyers, crushers, and pipes leading to fermenting tanks, shall not be excluded by the definition of pure sweet wine aforesaid; *provided, however,* that the cane or beet sugar, or pure anhydrous sugar, or water, so used shall not in either case be in excess of ten (10) per centum of the weight of the wine to be fortified under this act; *and provided further,* that the addition of water herein authorized shall be under such regulations and limitations as the Commissioner of Internal Revenue, with the approval of the Secretary of the Treasury, may from time to time prescribe; but in no case shall such wines to which water has been added be eligible for fortification under the provisions of this act where the same, after fermentation and before fortification, have an alcoholic strength of less than five per centum of their volume."

6. *Sparkling wine* is wine in which the after part of the fermentation is completed in the bottle, the sediment being disgorged and its place supplied by wine or sugar liquor, and which contains, in one hundred (100) cubic centimeters (20°C.), not less than twelve-hundredths (0.12) gram of grape ash.

7. *Modified wine, ameliorated wine, corrected wine,* is the product made by the alcoholic fermentation, with the usual cellar treatment, of a mixture of the juice of sound, ripe grapes with sugar (sucrose), or a sirup containing less than sixty-five (65) per cent. of sugar (sucrose), and in quantity not more than enough to raise the alcoholic strength after fermentation to eleven (11) per cent. by volume.

8. *Raisin wine* is the product made by the alcoholic fermentation of an infusion of dried or evaporated grapes, or of a mixture of such infusion or of raisins with grape juice.

(*b*) **Spirituous Liguors.**—*Brandy* is the alcoholic distillate obtained solely from the fermented juice of fruit, distilled under such conditions that the characteristic bouquet, or volatile flavoring and aromatic principles, is retained in the distillate.

Grape brandy is the distillate obtained from grape wine under these conditions.

Apple, peach, and other fruit brandies are similarly prepared from the fermented juices of the respective fruits.

The board is of the further opinion that so-called brandy prepared from grain, potato, or other form of industrial alcohol, or from alcohol obtained from the by-products of wine manufacture, mixed with more or less true brandy or other flavoring material, is adulterated and misbranded unless labeled to indicate its true composition.

(*c*) **Vinegar.**—1. *Vinegar, cider vinegar, apple vinegar,* is the product made from the alcoholic and subsequent acetous fermenta- of the expressed tions juice of apples.

2. *Wine vinegar, grape vinegar,* is the product made by the alcoholic and subsequent acetous fermentations of the juice of grapes.

3. *Malt vinegar* is the product made by the alcoholic and subsequent acetous fermentations, without distillation, of an infusion of barley malt or cereals whose starch has been converted by malt.

4. *Sugar vinegar* is the product made by the alcoholic and subsequent acetous fermentations of solutions of sugar, sirup, molasses, or refiner's sirup.

5. *Glucose vinegar* is the product made by the alcoholic and subsequent acetous fermentations of solutions of starch sugar or glucose.

6. *Spirit vinegar, distilled vinegar, grain vinegar,* is the product made by the acetous fermentation of dilute distilled alcohol.

Several questions regarding these definitions have been raised and after investigation the board has reached the following conclusions:

Meaning of the term "vinegar."—While the term, "vinegar" in its etymological significance suggests only sour wine, it has come to have a broader significance in English speaking countries. In the United States it has lost entirely its original meaning and when used without a qualifying word designates only the product secured by the alcoholic and subsequent acetous fermentation of apple juice.

"Second pressings."—It is held that the number of pressings used in preparing the juice is immaterial so long as the pomace is fresh and not decomposed. The practice of allowing the pomace from the presses to stand in piles or in vats for a number of days, during which time it becomes heated and decomposed, and then pressing, securing what is ordinarily called "second pressing," in the opinion of the board produces a product which consists in whole or in part of a filthy and decomposed material and is therefore adulterated.

Vinegar from dried-apple products.—The product made from dried-apple skins, cores, and chops, by the process of soaking, with subsequent alcoholic and acetous fermentations of the solution thus obtained, is not entitled to be called vinegar without further designation, but must be plainly marked to show the material from which it is produced. The dried stock from which this product is prepared must be clean and made from sound material.

Addition of water.—When natural vinegars made from cider, wine, or the juice of other fruits are diluted with water, the label must plainly indicate this fact; as, for example, "diluted to—— per cent. acid strength." When water is added to pomace in the process of manufacture, the fact that the product is diluted must be plainly shown on the label in a similar manner. Dilution of vinegar naturally reduces, not only the acid strength, but the amount of other ingredients in proportion to the dilution, so that reduced vinegars will not comply with the analytical constants for undiluted products; but the relations existing between these various ingredients will remain the same. Diluted vinegars must have an acid strength of at least 4 grams acetic acid per 100 cubic centimeters.

Mixtures of vinegars.—As different kinds of vinegar differ in source, flavor, and chemical composition, mixtures thereof are compounds within the meaning of the Food and Drugs Act, and if they contain no added poisonous or other added deleterious ingredients, will not be held to be misbranded if plainly labeled with the word "compound," together with the names and proportions of the various ingredients.

Addition of boiled cider and coloring matter.—The Food and Drugs Act provides that a product shall be deemed to be adulterated if it be mixed, colored, powdered, coated, or stained in a manner whereby damage or inferiority is concealed; and, in the opinion of the board, the addition of coloring matters, boiled cider, etc., to vinegar, wine vinegar, and the other types of vinegar, or mixtures thereof, is for the purpose of concealing damage or inferiority or producing an imitation product. In the first instance, the use of such products is an adulteration and therefore prohibited. Products artificially colored or flavored with harmless ingredients in imitation of some particular kind of vinegar will not be held to be misbranded if plainly labeled Imitation vinegar" in accordance with the provisions of the law.

Mixture of distilled and sugar vinegars.—The product prepared by submitting to acetous fermentation a mixture of dilute alcohol (obtained, for example, from molasses by alcoholic fermentation, and subsequently distillation) and dilute molasses, which has under gone alcoholic fermentation is, not "molasses vinegar" but a compound of distilled vinegar and molasses vinegar; such mixtures, however, must contain a substantial amount of molasses vinegar and not a small amount for the purpose of coloring the distilled vinegar. The molasses used must be fit for food purposes and free from any added deleterious substances.

Acetic acid diluted.—The product made by diluting acetic acid is not vinegar and when intended for food purposes must be free from harmful impurities and sold under its own name.

Product obtained by distilling wood.—The impure product made by the destructive distillation of wood, known as "pyroligneous acid," is not vinegar nor suitable for food purposes.

Acid strength.—All of the products described above should contain not less than four (4) grams of acetic acid per one hundred (100) cubic centimeters.

3. Salt

1. *Table salt, dairy salt*, is fine-grained crystalline salt containing on a water-free basis, not more than one and four-tenths (1.4) per cent. of calcium sulphate ($CaSO_4$), nor more than five-tenths (0.5) per cent. of calcium and magnesium chlorids ($CaCl_{22}$), nor more than one-tenth (0.1) per cent. of matters insoluble in water.

4. Preservatives and Coloring Matters

(Schedules in preparation)

5. Alimentary Pastes

Noodles, egg noodles, are dried alimentary pastes made from wheat flour and egg. They contain not less than five per cent. (5% by weight of the solids of whole, sound egg exclusive of the shell.

Plain noodles, water noodles, are dried alimentary pastes made from wheat flour without egg, or with less than five per cent. (5%) by weight of the solids of whole, sound egg exclusive of the shell.

Standards for moisture in these products are under consideration.

XI. DIET TABLE

There are many works on foods and dietics which contain lists of food substances purported to be grouped according to their relative food value, digestibility, caloric value, etc. These lists have some practical value but unfortunately most persons entirely overestimate the intrinsic worth of such lists. Even more misleading are the statements regarding the chemical composition off foods. Of late years dieticians have become quite reckless in the use of the term "vitamines." No one has as yet stated what vitamines are or what their chemical composition might be nor do we known just how they act when introduced into the system or just why the ill effects follow when inadequately supplied.

The following diet schedule arranged by Dr. Sipes is one of the latest and has many commendable features and it is hereby given with the brief introductory statement by the author.

A Convenient Diet Schedule

(By Glen J. Sipes)

The body calls for food in the following proportions to maintain health and efficiency:

63 per cent. heat-producing;
16 per cent. muscle-building;
3 per cent. brain and nerve repair;
7 per cent. waste to assist digestive and eliminative functions:
11 per cent. moisture.

This, of course, applies to the average person.

Where the daily occupation calls for special emphasis upon the muscular system, the diet should consist more and more of the muscle-building foods. For the sedentary person who uses the brain constantly the diest should be regulated very carefully and consist more of the nerve feeding type of food.

By adding vertically and horizontally and dividing the result by the number of foods selected, a net result will be shown totaling 100 per cent.

An Analysis of Foods in the Natural State, Showing the Percentage Each Article Contains of Heat, Strength, Nerve, Water and Waste Products

Article	Carbonates Heat, Fat or Weight	Nitrates Muscle or Strength	Phosphates Brain and Nerve	Waste	Water
Apples, sweet	13.00	4.00	1.0	2.00	80.00
Apples, sour	8.00	5.	1.5	2.00	83.5
Artichoke	19.00	1.9	1.8	.7	76.6
Asparagus	5.4	.6	.4	0.00	93.6
Bacon	62.5	8.4	.5	0.00	28.6
Barley	52.1	12.8	4.2	16.9	14.
Barley, pearl	78.00	4.5	1.	7.	9.5
Beans, dry	40.	24.	3.5	17.7	14.8
Beans, green	5.00	2.60	1.4	4.	87.
Beef	14.00	19.00	2.00	0.00	65.00
Beets	8.00	1.2	1.00	1.00	88.8
Blackberries	10.5	.9	1.35	1.75	85.50
Buckwheat	53.00	8.6	1.8	22.4	14.2
Butter	86.00	1.00	0.00	2.5	10.5
Cabbage	6.2	1.2	.5	.5	91.6
Cantaloupe	5.00	3.00	.8	1.2	90.00
Carrots	12.3	1.00	1.00	3.2	82.5
Cauliflower	4.6	3.6	1.00	.8	90.00
Carp	.8	18.00	2.9	0.00	78.3
Chicken	1.9	21.6	2.8	0.00	73.7
Clam	.8	7.00	2.4	3.00	86.8
Cheese	34.00	27.	3.00	1.00	35.00
Cherries	20.00	.8	1.5	1.6	76.1
Chocolate	74.0	16.	2.5	1.5	6.00
Cocoa	70.00	20.00	4.00	1.00	5.00
Cod fish	1.00	16.5	2.5	0.00	80.00
Corn (maize)					
Corn Northern	67.5	12.3	1.1	5.1	14.0
Corn Southern	39.2	34.6	4.1	8.1	14.0
Corn, sweet	18 75	3.00	1.25	2.00	75.00
Crab	.5	15.	6.5	3.	75.00
Cream	5.	3.5	.5	0.00	81.5
Cucumber	1.7	.1	.5	.6	97.1
Currants	6.7	1.00	1.00	10.00	81.3
Dates	70.4	2.00	1.4	2.2	24.00
Eel	1.00	17.00	3.00	4.00	75.00
Eggs, white	.4	13.00	2.8	.8	83.00
Eggs, yolk	29.8	16.9	2.00	.3	51.00
Eggplant	5.00	1.00	.5	3.5	90.00
Figs	57.9	5.00	3.4	15.	18.7
Flounder	1.00	15.00	3.00	3.00	78.00
Flour, graham	74.56	12.65	1.8	2.38	8.61
Flour, high patent	77.95	10.64	.42	.5	10.49
Grapes	13.00	1.5	1.5	1.00	83.00
Grapefruit	8.00	1.00	1.5	3.5	86.00
Green gages	23.5	.5	.4	1.6	74.00
Haddock	1.6	15.	2.6	3.8	77.00
Halibut	3.5	18.	3.5	3.	72.00
Ham	35.	35.	2.	25.	30.00
Herring	2.	19.00	3.	4.	72.00
Honey	75.	0.00	.5	.5	24.00
Horseradish	3.2	.4	1.00	16.4	79.00

Article	Carbonates Heat, Fat or Weight	Nitrates Muscle or Strength	Phosphates Brain and Nerve	Waste	Water
Jams	55.1	3.	.9	1.	40.9
Jells	61.2	.5	.3	0.00	38.0
Kidney	1.5	24.5	2.5	1.5	70.0
Lamb	14.5	19.6	2.	2.4	61.5
Lard	86.	.5	.3	.7	12.5
Liver	4.5	25.5	2.5	4.3	63.2
Lemon	2.	.95	2.	4.25	90.8
Lentils	38.00	28.	1.5	18.5	14.0
Lettuce	2.5	1.5	.5	2.5	93.0
Lobster	.5	14.	6.	3.5	76.00
Melon, water	5.00	2.00	.5	.5	92.00
Milk, cow	6.	4.	1.	1.4	87.6
Milk, human	7.90	3.00	.5	1.	88.5
Molasses	45.	1.	0.00	5.	49.0
Muskmelon	5.5	3.5	.8	.12	89.0
Mutton	14.	21.	2.	2.	61.0
Nuts, average	70.	20.	2.	2.	6.0
Oats	72.	17.	3.	3.	5.0
Onions	5.2	1.	.5	1.5	91.8
Oranges	10.00	1.1	2.00	.9	86.00
Oysters	.7	5.5	2.6	2.2	89.0
Parsnips	4.5	2.1	1.	3.00	89.4
Parsnips	7.	7.0	0.00	4.00	82.00
Peaches	10.00	1.5	.5	1.	87.00
Pears	9.5	1.2	.3	3.5	85.5
Peas	41.	23.4	2.5	19.	14.1
Pigeons	9.	23.00	3.00	2.5	62.5
Plaice	1.	15.00	3.00	3.00	78.00
Plums	8.5	1.5	1.5	1.5	87.00
Pork	16.	17.5	1.8	1.7	63.00
Potatoes	16.5	1.5	.5	2.00	79.5
Potatoes, sweet	21.8	1.5	2.9	6.3	67.5
Prunes	75.	4.00	4.5	2.5	14.0
Pumpkin	4.0	3.0	.5	3.0	89.5
Radish	7.4	1.2	1.00	1.3	89.1
Rice	82.00	5.1	.5	9.00	3.4
Rye	71.2	10.00	1.00	4.3	13.5
Salmon	1.00	20.00	6.5	1.5	71.00
Shrimp	.4	16.	7.	3.6	73.0
Smelt	1.5	18.5	6.5	1.5	72.00
Sole	.8	17.00	2.5	1.7	78.00
Sorghum	71.50	1.50	0.00	7.00	20.00
Spinach	4.5	2.1	.4	3.00	90.00
Squash	6.00	4.00	.5	2.00	87.5
Strawberries	5.5	1.00	1.00	1.5	91.0
Suet	98.	1.00	0.00	.9	00.1
Syrup	75.00	0.00	0.00	1.00	24.00
Tomatoes	4.00	2.00	.5	1.5	92.00
Trout	.8	16.9	5.5	1.8	75.00
Turbot	1.00	14.00	5.5	1.5	78.00
Turnips	4.00	1.2	5	3.9	90.4
Veal	14.3	17.7	2.3	2.7	63.00
Venison	8.00	20.4	2.8	2.6	66.2
Vermicelli	74.00	11.5	.3	1.2	13.00
Wheat	72.59	12.26	1.2	3.14	10.81
Whey	5.5	.4	.6	.5	93.00
Whiting (a fish)	1.5	15.5	5.5	1.5	76.00

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